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25X1

RD-3M-500
ENGINE DESCRIPTION
(English language)

SECRET

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GROUP 1
Excluded from automatic
downgrading and
declassification

РД-3М-500 ENGINE

DESCRIPTION

Y K "AVIAEXPORT"

USSR

MOSCOW

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Chapter I ENGINE CONSTRUCTION

I. GENERAL

- a. Two-stage gas turbine,
exhaust unit,
engine wheelcase and accessory drive gear.
- b. C300M fuel-air combustion starter, with
series, which together with the electrical and fuel



Fig. 1. C300M 500 Engine, Left-Hand View

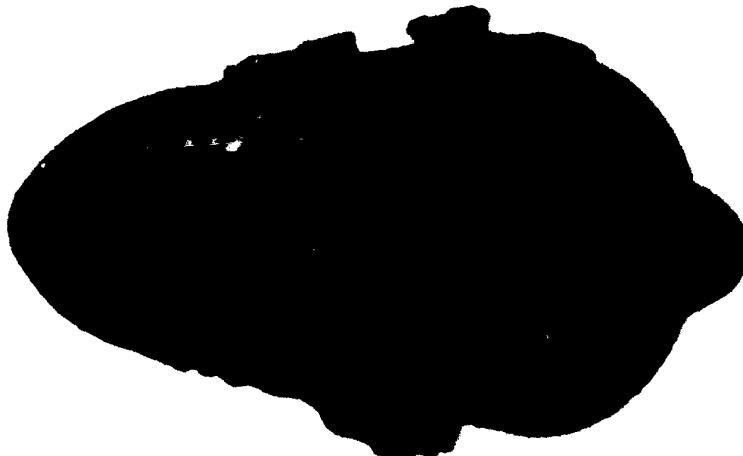


Fig. 2. C300M 500 Engine, Three-Quarter, Right Front View

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systems, ensures independent automatic starting of the engine.

The compressor with a 6.4 pressure ratio compresses the air entering through the inlet duct and delivers it into the combustion chamber.

About one third of the total amount of air is mixed in the combustion chamber with the atomized fuel delivered through the main burners and takes part in the combustion process.

2. SPECIFICATIONS

1. General

Engine designation	PZ-3M 500
Type of engine	turboprop
Compressor	
type	axial flow
number of stages	8
pressure ratio	
at emergency rating	7.2
at maximum rating	6.4

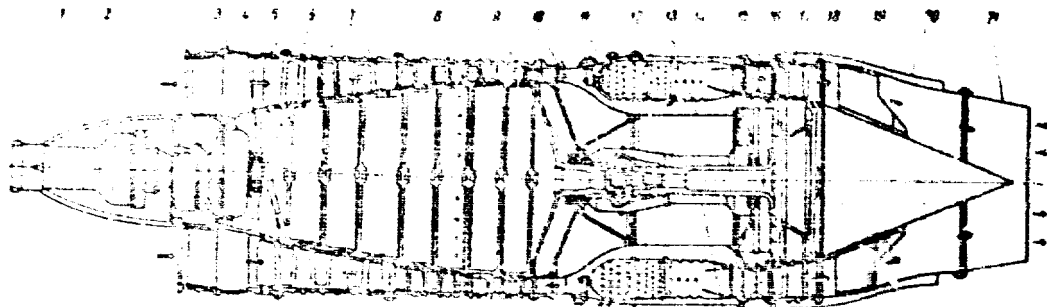


Fig. 3. PZ-3M 500 Engine Diagrammatic View

1 - front casing with starter rating; 2 - front combustion chamber; 3 - compressor front casing; 4 - front support; 5 - front casing; 6 - front casing; 7 - front casing; 8 - front casing; 9 - front casing; 10 - front casing; 11 - front casing; 12 - front casing; 13 - front casing; 14 - front casing; 15 - front casing; 16 - front casing; 17 - front casing; 18 - front casing; 19 - front casing; 20 - front casing; 21 - front casing; 22 - front casing.

The remaining air mixing with the products of combustion reduces their temperature to the level which is consistent with the heat-resisting capacity of the turbine blades.

The turbine expansion ratio (3.5) utilizes part of the energy of the hot gases for rotating the turbine and accessories. The remaining energy of the gases is converted into engine thrust in the exhaust unit.

The engine rotor is made up of the compressor and turbine rotor, the two being interconnected by a splined coupling incorporating a torque-transmitting shaft.

The engine rotor (Fig. 3) is mounted on three supports: front support 4, middle support 9 and rear support 10 located respectively in the front of the compressor casing and in the rear of the turbine casing.

The load-carrying portion of the engine rotor is supported by front 4, middle 9 and rear 10 supports. The compressor, combustion chamber, 1st stage nozzle assembly and turbine shaft are connected by a splined coupling system.

The engine is designed for operation on kerosene fuel.

Peculiarities of design	automatic air blow-off mechanism for delivery of air from chamber after 3rd stage
Combustion chamber	
type	straight-flow with individual flame tubes in common casing
number of flame tubes	14
arrangement	circumferentially about engine axis
numbering	counter-clockwise looking from exhaust unit end and taking upper left chamber for No. 1 chamber
Turbine	
type	axial flow
number of stages	2
Exhaust unit	
type	non-adjustable
diameter of jet nozzle, mm	640-661
Engine rotor rotation	counter-clockwise looking from exhaust unit side according to layout coordinated with Aircraft Manufacturing Plant
Engine-to-mount attachment	
Engine equipment	
1) anti-icing system supplying air heated in compressor	
- from chamber after compressor stage VII for heating starter fairing and covering struts	
- from pressure balance chamber of compressor front	

Attachment to

- casing for heating vane edges of guide vane assembly.
- 2) flanges on compressor casing for bleeding air to aircraft anti-icing system
- number of flanges 1
- point of air bleed from chamber after compressor stage VIII
- amount of air bled at nominal rating $400 \pm 50 \text{ kg/hr}$
- 3) flanges on compressor casing to bleed air for pressurized cabin:
- number of flanges 4
- point of air bleed from chamber after compressor stage VIII
- amount of air bled $600 \pm 30 \text{ kg/hr}$
- Composition of air supplied for pressurization (oxygen, nitrogen, fuel fumes and products of pyrolysis) corresponds to G11-58, Part I, Paragraph 343.

The analysis is made during endurance tests.

- Notes: 1. The amount of bled air given above is valid for standard atmospheric conditions.
2. The use of the anti-icing system is outlined in the Operating Instructions.

Main Ratings

Emergency rating

may be used at temperatures above $+15^\circ\text{C}$ in case of failure of one engine during take-off.

After operation at emergency rating the engine may be run three more hours provided there are no causes for stopping the flight. Then the engine must be removed from service and overhauled at the Plant.

Rotor speed, r.p.m. 4900 ± 15

Note: Engine thrust and speed are corrected to standard atmospheric conditions.

The parameters of the emergency rating can be checked only during endurance tests at emergency R.P.M. which are either equal to the Plant setting or restricted by the setting in the governor for low temperatures.

The parameters of the emergency rating are not checked during the acceptance and trial tests and are guaranteed by the guaranteed characteristics of the engine.

The speed of the emergency rating and acceleration of the engine from the maximum to the emergency rating are checked and checked during the acceptance and trial tests with the jet nozzle removed.

Temperature of gases after turbine (measured and corrected) with engine running steadily on ground: 780 max

Number of emergency rating periods during a 10 hr life of engine: 1 with subsequent removal of engine from aircraft

Time of continuous operation during emergency rating period: 2 max

Maximum corrected rotor speed, r.p.m. 4900 ± 25

Maximum speed in flight, r.p.m. 4900 ± 30

Maximum speed in flight, r.p.m. 4900 ± 30

Maximum speed in flight, r.p.m. 4900 ± 30

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Maximum speed in flight, r.p.m. 4900 ± 30

Maximum speed in flight, r.p.m. 4900 ± 30

Maximum speed in flight, r.p.m. 4900 ± 30

In flight 720 max

with engine anti-icing system

control valve "ON" 140 max (more accurate data are obtained with experience gained; 5 min)

Duration of continuous operation, min

At $+15^\circ\text{C}$ ambient temperature the maximum engine R.P.M. on ground and at altitudes up to 2400 m are limited by the maximum capacity of the fuel pumps which in turn is limited by the wobble plate stop.

Rotor speed (governed) with engine control lever at max. rating stop 4900 ± 30

- Notes: 1) As the engine gains speed, the temperature of the gases after the turbine should not exceed 720°C with gradual driving up of the engine speed within $1-1.5 \text{ min}$, down to the specified value.
- 2) The temperature of gases after the turbine is read off the indicator as a mean value (the average sensed by four thermocouples equispaced around the exhaust unit).
- 3) In flight, while gaining height, the engine speed is allowed to reach 4700 r.p.m. the height limit is subject to more accurate definition later.

Nominal Rating

Rotor speed, r.p.m. 4900 ± 25

Temperature of gases after turbine (actual), $^\circ\text{C}$ 780 max

of steady operation (measured and corrected) 615 max

in flight 615 max

while air is being bled into engine and aircraft deicing systems

Duration of continuous operation, min

on ground 1 max

in flight not restricted

08 Nominal Rating:

Rotor speed, r.p.m. 4900 ± 25

Temperature of gases after turbine (measured and corrected) at steady operation, $^\circ\text{C}$ 540 max

Idle rating

Rotor speed, r.p.m. 1750 ± 5

Temperature of gases after turbine (actual), $^\circ\text{C}$ 520 max

Duration of continuous operation not restricted

Maximum critical speed during bench test (corrected), r.p.m. 5530 max

Acceleration characteristics:

1) from idle rating ($1750 \pm 5 \text{ r.p.m.}$) to maximum rating ($4900 \pm 25 \text{ r.p.m.}$) with engine control lever advanced in $1-2 \text{ sec}$ 17 max

At ambient temperature below $+15^\circ\text{C}$ the acceleration time may be estimated from IDLE rating ($1750 \pm 5 \text{ r.p.m.}$) to 50 r.p.m. below the adjusted maximum rating speed.

Under such conditions acceleration time in sec should be 11.5 max

2) from $1750 \pm 5 \text{ r.p.m.}$ to 3600 r.p.m. 7 max

The engine should show satisfactory acceleration characteristics when acceleration is checked from $1600 \pm 5 \text{ r.p.m.}$

Note: While checking engine acceleration from $1600 \pm 5 \text{ r.p.m.}$ the time of acceleration is not specified.

3) from beginning of adjustment control (3500 r.p.m.) to $4900 \pm 25 \text{ r.p.m.}$ (engine control lever is advanced from 3500 r.p.m.) 12-15

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Attachment to

At ambient temperatures below +15°C it is allowed to estimate the acceleration time from beginning of automatic control (1000 r. p. m.) to a speed by 50 r. p. m. less than the adjusted maximum rating speed. Under these conditions the acceleration time in sec. should be:

- 4) from maximum rating (1700-2300 r. p. m.) to a speed by 50 r. p. m. less than the adjusted engine rating speed.

Maximum permissible rotor speed during acceleration test ("overspeed"):

- acceleration to maximum rating;
- acceleration to emergency rating.

115-135

4 max.

4000 max.

rotor speed is allowed to be by 50 r. p. m. higher than adjusted value

710 max.

300 max.

Maximum permissible temperature of gases in exhaust unit during acceleration test to maximum rating engine speed.

Exhaust temperature from maximum to PM101100 rating allowance is made for momentary overtemperature of gases in exhaust unit (measured).

Note: Permissible variation in gas temperature after the turbine at maximum rating is ±10°C

Engine life before first overhaul, hrs. 500

1000 hrs. as:

- maximum rating operation, hr. 30
- maximum rating operation, hr. 150

All other ratings the engine operating time is not limited. The engine service life is calculated as follows: engine operation in the air is considered 100%, whereas actual engine operation on the ground is accounted 20% as compared with engine operation in the air.

FUEL SYSTEM

Grades of fuel used:

main fuel

starting fuel

IC-1 fuel, FOCT 7149-54 or T-1 fuel, FOCT 4135-49 aviation gasoline B-70, FOCT 1012-51 plus 1% (by weight) of MK-8 oil, FOCT 6457-53 or transformer oil, FOCT 982-56 of any grade (with and without BTH-1 additive)

Starting fuel pump:

type

purpose

number

starting fuel pressure, kg/cm²

starting burners

type

purpose

14-175

centrifugal supply of atomized fuel at engine starting

4 (in combustion chambers Nos. 3, 10 and 12)

Fuel boost pump:

type

purpose

transmission ratio

rotation

number

Fuel pressure at LH-14 boost pump

inlet (abs), kg/cm²

Regulating fuel pumps:

type

purpose

LH-14, centrifugal supply of main fuel to regulating fuel pumps 1765 clockwise (looking from drive end)

0.16-1.6

PH-15B and PH-26B

supply of fuel at starting and service operation of engine. Control of engine and regulation of predetermined engine R.P.M. at all altitudes and flying speeds (beginning with automatic control speed with engine control lever stationary) regulation of fuel supply to engine during acceleration, and maintenance of minimum permissible fuel pressure at all altitudes

0.95

counter-clockwise (looking from drive end)

1500-4900

1.8-3.2

transmission ratio

rotation

automatic control range, r. p. m.

fuel pressure at pump inlet, kg/cm²

Main burners:

type

purpose

number

Fuel pressure before main burners,

kg/cm²

point of pressure measurement

centrifugal, two-chamber, two-stage supply of atomized main fuel into engine combustion chambers

14

66 max.

on primary manifold

LUBRICATING SYSTEM

Oil grades used

MK-8, FOCT 6457-53 or transformer oil, FOCT 982-56 of any grade (with or without BTH-1 additive)

Notes: 1. To ensure reliable engine starting at ambient air temperatures below -25°C it is recommended to dilute the oil with non-ethylated B-70 gasoline, FOCT 1012-51, adding 15-18% of the oil volume in the system.

2. B-70 gasoline may be substituted by starting fuel (B-70 gasoline with 1% by weight of MK-8 oil or transformer oil)

Oil consumption, kg/hr

1.5 max.

Rate of oil flow through the engine at nominal rating and at maximum permissible and recommended temperature of oil at engine inlet, *lit./min*

33-5

Minimum quantity of oil in tank at which engine operation is still possible

depends upon type of aircraft oil system and is specified in Aircraft Operating Instructions

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Oil pressure in main oil line, kg/cm^2
— at emergency, maximum, nominal
and 0.5 nominal ratings 15—45
— at idle rating 1 min
Point of oil pressure transmitter installation on pipe leading oil
to intermediate drive
after oil filter
Oil engine inlet temperature, $^{\circ}\text{C}$.
— maximum permissible 80
— minimum permissible 10
— recommended 10—50
Maximum permissible oil outlet temperature, $^{\circ}\text{C}$ 105
Heat transfer to oil at nominal rating and at maximum permissible temperature, Cal/min 100 max.
Oil pump:
type gear
purpose delivery and scavenging of engine oil
number of sections 4 in one casing
One delivery section and three scavenging sections
Delivery section:
transmission ratio 0.827
capacity at nominal rating and 1.5 kg/cm^2 counter pressure, lit/min 60 min
Scavenging section:
transmission ratio 0.827
Capacity at nominal rating and 0.5 kg/cm^2 counter pressure, lit/min 60 min
1st section 60 min
2nd section 60 min
3rd section 60 min
Breather:
type controlled
purpose removal of oil from engine vent system, outlet air
transmission ratio 2.96

STARTING SYSTEM

Type of starting system independent automatic, consisting of C-80M starter, tachometer generator, starting relay box
Starter:
type gas turbine engine
purpose independent automatic starting of engine
starting speed range, r.p.m. 3100—3350
output power at gas temperature in exhaust pipe not over 650°C , H.P. 90—100
fuel consumption at operating speed, kg/hr 35—100
maximum temperature of gases in exhaust pipe at operating speed with an ambient temperature, $^{\circ}\text{C}$.
below $+15^{\circ}\text{C}$ 640 max.
above $+15^{\circ}\text{C}$ 700 max.
starting starter motor 800 max.
maximum permissible speed of starter, r.p.m. 3000 max.
duration of starter operating cycle after depressing START button, sec 10 max.
START service life (number of operations) 20
maximum service life (minutes) from 100 AMPS storage battery (100 amp-hr) 15 min

Number of automatic engine startings in succession not over 4 with 15-minute intervals between startings and a 15-minute cooling interval after 4th starting
Number of operating cycles of CA-175B.M. electric starter not over 5 with 4-minute intervals and a 15-minute cooling interval after 5th cycle
Tachometer generator:
type TGT-43
purpose at starting supplies electric energy to relay, not to control voltage in relation to engine speed
number 5
Relay box:
type RT-43
purpose automatic control and control of starting units
allowable number of operating cycles—5 with 4-minute intervals and a 15-minute interval after 5th operating cycle. There should be not more than 4 automatic startings out of 5 operating cycles of relay box
number 3 max.
Total consumption of fuel per one engine starting, kg 640 max.
Maximum temperature of gases in engine exhaust unit at starting, $^{\circ}\text{C}$ 640 max.
Time for gaining (IDL rating speed (1750—2000 r.p.m.) after depressing START button, sec 120 max.

The engine is equipped with an emergency starting plug connector for starting the autorotating engine from the generators in case of storage battery failure.
The use of emergency starting is described in the Operating Instructions.

IGNITION, ELECTRICAL AND CONTROL SYSTEMS

Type of ignition electric erosion type, surface discharge from D.C. coils
Booster coil unit:
type FBNH-2P1
purpose supply of H.T. current to engine spark plugs
number 4
supply voltage, V 12—23.6
Starting spark plugs:
type CNH-43, electric erosion surface discharge type
purpose ignition of main fuel at engine starting
number 4

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Air blow-off band mechanism for bypassing air from chamber ~~into~~ compressor stage III.

type
air pressure in air blow-off band control system, kg/cm²

Air reducer:

Automatic electromagnetic air valve:

type

purpose

number

supply voltage, V

Centrifugal transmitter controlling compressor air blow-off band mechanism:

type

purpose

number

transmission ratio

number

Starter exhaust pipe shutter control mechanism (not included in engine standard equipment):

type

number

Emergency rating control mechanism:

type

purpose

number

Pneumatic contactor:

type

purpose

number

air, piston

40-50

1

25M, electromagnetic

control of air supply

into air blow-off band mechanism

1

135-30

LLI-3, centrifugal,

single duty

provides, at predetermined engine

speed, for automatic operation of

electromagnetic air valve in air blow-off band control

mechanism

1.33

1

MSK-2, electromechanical

with BMT-25 electromagnet

limiting maximum rating speed and

permitting gain of emergency rating speed

1

1

PIK, membrane

automatic control of starter exhaust

pipe shutter control mechanism

1

AIRCRAFT ACCESSORIES

Generators:

type

purpose

rotation

transmission ratio

number

Air compressor:

type

purpose

rotation

transmission ratio

number

FCP-1800M,

shunt-excited

supply of aircraft

electrical system

counter-clockwise

(looking from drive

end)

1.875

2

AK-150H,

reciprocating supply

of compressed air

to aircraft pneumatic

units

clockwise (looking

from drive end)

0.428

1

Hydraulic pump:

type

purpose

rotation

transmission ratio

number

435B⁰, plunger
building up pressure in aircraft hydraulic system
clockwise (looking from drive end)
0.468
1-

Note AK-150H, 435B⁰ units and FCP-1800M generators are furnished with the engines.

3. ARRANGEMENT OF UNITS

The engine incorporates three accessory drives, namely: the R.H. and L.H. intermediate drives located on top of the compressor front casing, at 30° to the vertical axis of the engine, and the lower drive located at the right-hand bottom part, also at 30° to the vertical axis of the engine.

The R.H. intermediate drive actuates the AK-150H air compressor, whereas the L.H. intermediate drive transmits motion to the centrifugal breather and has two flanges for the engine tachometer transmitters.

The PIT-4B relay box is installed between the intermediate drives.

Mounted in a common casing on the lower drive are three scavenge oil pumps and one delivery oil pump; besides, there is also the PIH-121 centrifugal booster fuel pump with an anti-over-pressure device.

The R.H. and L.H. intermediate drives transmit the engine torque to the engine wheelcase and accessory drive gearbox, respectively; these units are located on the top of the compressor middle casing at 30° to the vertical axis of the engine.

Mounted on the engine wheelcase are PIH-25b and PIH-15b regulating fuel pumps, LLI-3 centrifugal transmitter which controls the air blow-off band, and the engine oil filter.

Two FCP-1800M generators and the 435B⁰ hydraulic pump are mounted on the accessory drive gearbox.

The KPIH4-2P1 booster coil unit is located on the middle casing of the compressor, between the generators and the fuel pumps mounted on the engine wheelcase.

Mounted in the front part of the compressor middle casing (top, left) are the electromagnetic air valve and the air reducer 52512700; the pneumatic contactor and the CJL-24A unit are located on top and to the right. The blow-off tank is mounted on the compressor middle casing, under the engine wheelcase.

In the lower part of the compressor middle casing are located the PIH-10-3M starting fuel pump, electromagnetic fuel valve, blow-off valve, drain tank and the KPIH4-2P1 booster coil unit.

* The terms "left-hand" and "right-hand" used in this Manual refer to the viewpoint of an observer looking at the engine from the exhaust unit side. The term "front" and "rear" refer to the air inlet and exhaust unit ends of the engine, respectively.

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On the rear casing of the compressor are located the main and starting fuel manifolds.

The manifold for discharging air from the pressure relief chamber of the compressor rear casing is located on the combustion chamber casing.

The pressure relief chamber of the compressor rear casing communicates with the air discharge manifold through four pipes installed between the flame tubes. The fifth pipe is used for measuring pressure in the pressure relief chamber.

The engine is fitted with two interconnected fire manifolds for delivering fire-extinguishing fluid into the engine nacelle, if necessary.

Note: The purpose and operating principle of the aforementioned units are dealt with in the relevant chapters.

The G-300M gas turbine starter is fastened to the compressor front casing and is closed with an easily detachable fairing.

The PD-3M engine is a modification of the PD-3M engine and incorporates a number of structural improvements which extend its service life.

This Manual contains but a brief technical description of the engine and is intended for studying the design of the PD-3M engine only jointly with the technical description of the PD-3M engine published in the relevant chapters.

4. MAIN POINTS OF DIFFERENCE BETWEEN PD-3M AND PD-3M

Compressor

Compressor Rotor

- a) the side surfaces of the 3rd and 4th stage blade locks have been subjected to cold working;
- b) 7th and 8th stage blades are made of 13X14HBQPA material;
- c) the rear hub has been fitted with a pressed-on labyrinth having increased interference and different shape.

Compressor Middle Casing

- a) hatches have been cut in the casing above each stage for measuring radial clearances and examining the blades without disassembling the engine;

- b) the diameter of the hubs of the 7th stage stator vanes has been increased from 15 to 20 mm; the tower hubs have been fitted with keys;

- c) salt treatment of the compressor middle casing above the 6th stage of the rotor blades has been deleted;

- d) the 4th and 5th stage stator vane hubs have been subjected to cold working.

Compressor Front Casing Guide Vanes

- a) the vane mounting has been made thicker and the holes have been enlarged through which air is fed into the vanes;

- b) the upper hubs of the guide vanes have been fitted with longer bushings made of surface-nitrated 13X14HBQPA material.

Compressor Rear Casing

- a) all the stator vanes (80 in number) are made of 3M 63 steel;
- b) before screwing on the nuts, the vane hub threading is coated with chalk compound;
- c) the tubular oil feed adapter has been replaced by a welded elbow pipe;
- d) the oil discharge and breathing elbow flanges have been made thicker and provided with grooves.

Middle Support

- a) middle support bearing lubrication has been improved;
- b) the bearings are fitted on the rear hub with a guaranteed interference;
- c) spacer rings have been reinforced to prevent possible application of load to a single bearing.

Combustion Chamber

- a) retainers have been reinforced;
- b) the larger cross-fire tube is argon-welded by corner joint and the smaller cross-fire tube is made floating;
- c) the main burner has been provided with a thicker body flange; the radius of the sleeve has been increased from 40 to 170 mm; the sleeve is made of 13X14HBQPA;
- d) the spherical surface of the igniter is provided with fused-on heat-resistant alloy; the igniter retainer tip has been made shorter and a bailer has been introduced for directing air onto the spark plug.

Turbine

Turbine Rotor

- a) the width of the 1st stage disc rim has been increased on the outer diameter and on the diameter of the fir-tree groove bottom;
- b) two labyrinth projections have been substituted by one, located below the fir-tree groove bottom;
- c) slanting holes for the passage of the cooling air between the slots have been substituted by ten 11 mm dia. holes located on a smaller diameter;
- d) the width of the 2nd stage disc rim has been increased on the outside diameter and on the diameter of the fir-tree groove bottom; the shield has been deleted;
- e) the 1st and 2nd stage blades have been fitted with 4-tooth lock.

1st Stage Nozzle Assembly

- a) the nozzle assembly vanes are made of XC-6K alloy and have a larger inlet radius;
- b) the bolts of the nozzle assembly frame supports have been reinforced;

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c) shorter fairings of 3H-602 material have been installed.

2nd Stage Nozzle Assembly:

Now the shoes have only one labyrinth located on the front face, instead of the former two.

Shafting Casings:

a) the telescopic joint of the middle and rear casings has been replaced by a screwed joint. The necessary freedom of the middle casing with respect to the rear one is provided for by the use of a "harmonic" compensator.

Rear Support:

The new seal of the rear support has brass-coated knife edges on the covers, the bushings on the shaft being smooth.

The shaft is now provided with three holes for feeding air into the seal. The number of the oil feed nozzles has been increased from 5 to 6.

Exhaust Unit

a) a reinforced gasket is placed between the flanges of the turbine 2nd stage nozzle assembly shroud and that of the exhaust unit;

b) the bolts fastening the exhaust unit to the nozzle assembly shroud and those holding the jet nozzle to the exhaust unit are made of 3H-437B material;

c) the bosses used for fastening the drain pipes to the jet nozzle are riveted in place;

d) the cut-outs for the drain pipes have been substituted by bending-in the band.

Engine Accessory Drives

a) the walls of the hollow cast struts in the compressor front casing have been made thicker, the covering struts are of the cast type and pro-

vided with deflectors. Additional ribs are made on the rear wall of the front support.

The length of the bushing supporting surface has been increased;

b) the L.H. and R.H. intermediate drives have been reinforced, the sleeve bands and the journals of the driving and driven gears are now case-hardened;

c) the body casting of the central drive has been changed, and steel case-hardened bearing bushes are now used. The design of the jet feeding oil to the front support has been altered. The gears have been fitted with retainers.

Lubricating System

The second-stage oil filter has been replaced by an easily removable high-capacity filter.

Fuel System

A new flow-off valve has been installed for feeding fuel into the primary manifold.

Anti-Icing System

a) the guide vanes are provided with a wider slot for admission of heating air;

b) the covering struts are of cast construction and provided with deflectors;

c) the supporting surface of the air inlet pipe has been enlarged at the points of attachment. The pipe is locked against turning.

Fuel-Air Combustion Starter

a) the starter rotor is mounted on rolling friction bearings, viz. a roller bearing at the turbine disc end and a ball bearing at the compressor impeller end;

b) the hydraulic coupling gear has been reinforced.

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Chapter II

DESCRIPTION OF ENGINE UNITS

I. COMPRESSOR

The axial flow eight-stage engine compressor is used to compress the air before it is forced into the combustion chambers.

The main components of the compressor (Fig. 4) are the rotor, stator vanes 7 and the casing consisting of front 2, middle 4 and rear 9 casings.

A peculiar feature of the compressor design is the air blow-off band after the 3rd stage which ensures steady performance of the compressor at intermediate ratings (up to 3,550 r.p.m.). To reduce undue interflow of air the compressor stages are vacuum-treated (see description of the compressor middle casing).

The compressor rotor is of the drum-disc construction and consists of eight discs 8 and two hubs 5 and 10 built as a single non-dismountable assembly.

The discs are statically balanced before assembly, then connected along the centering bands to one another (with a certain interference) and to the hubs by means of radial dowels. The assembled rotor is subjected to dynamic balancing by interchanging the blades of the 1st, 2nd, 7th and 8th stages within the limits of one disc by screwing in and cutting off the balancing weights in the dowels of the 1st, 7th and 8th discs and by deepening the holes in the 1st stage disc.

The permissible rotor unbalance is 40 gcm.

The front hub cone as well as the first six discs are made of AK4-1 aluminum alloy.

The blades installed on these discs are made of B1-17 aluminum alloy and the blade locks are of the dovetail type.

The last two discs and the rear hub subjected to higher thermal stresses are made of OXH3A steel whereas the blades of these discs are of 13X14HBΦPA steel; the locks of these blades are of the fir-tree type.

The blades are fixed longitudinally on the discs by means of plate locks and tapered dowels.

The compressor rotor is mounted on two supports: the front support is a roller bearing taking the radial loads; the rear support is a two-row ball bearing taking both the radial and axial stresses. The supports are located in the compressor front and rear casings, respectively.

The holes in the cylindrical band of the 5th stage disc and in the disc walls allow the inside space of the rotor to be filled with air under a uniformly high pressure. This creates an identical pressure applied from both sides to the wall of each disc. Besides, passing into the front pressure relief chamber through the holes in the front hub cone, the air reduces the axial loads imposed on the compressor and seals the front support.

The compressor front casing is a magnesium casting consisting of an inner box and outer rim interconnected by six hollow struts. Fastened to the front and rear flanges of the inner box are respectively, the central drive and the insert with an oil trap.

The central drive is housed in the front casing inner box.

The front roller bearing of the compressor rotor is installed in the wall of the front casing. The rear portion of the front casing annular duct houses the compressor guide vanes. The latter are arranged at a certain angle and are locked in place by means of dowels installed in the compressor front casing.

On the top part of the compressor front casing are installed the R.H. and L.H. intermediate drives and the relay box; the lower drive is mounted on the right bottom part of the casing.

Fastened to six struts of the front casing are cast-type covering struts. The inside spaces of the front casing struts are utilized for installing the coupling shafts of the intermediate and lower drives; the inner spaces of the cast-type covering struts accommodate the oil, fuel and air pipes, and electric wires.

Installed in the upper inclined struts of the front casing are the coupling shafts transmitting rotation to the intermediate drives in the left strut; besides, the front casing breathing pipe and the central drive oil feed pipe are also installed there.

Housed in the upper cast covering struts are the following parts: in the R.H. strut — the pipe accommodating the thermocouple wire, the pipe for measuring oil pressure in the starter, and the bunch of electrical wires leading to the starter; in the L.H. strut — the air feed chamber of the engine anti-icing system.

S-E-C-R-E-T

Attachment to

25X1

Extending through the R.H. lower strut of the front casing are the lower drive coupling shaft and the pipe for draining oil from the compressor front casing.

Located in the lower cast-type covering struts are the following parts in the L.H. strut—the pipe for scavenging oil from the lower oil collector (by the scavenge suction of the starter oil pump) and the pipe leading oil to the starter; in the R.H. strut—two pipes for draining fuel from the starter and the pipe for directing oil into the tank.

The pipe draining oil from the engine wheelcase is located in the R.H. horizontal strut of the front casing.

The L.H. horizontal strut of the front casing houses the pipe for draining oil from the accessory drive gearbox and the centrifugal breather. The inside space of the front casing L.H. strut is used for venting the oil tank through the pipe union of the pipe elbow.

The R.H. horizontal covering cast-type strut accommodates the fuel and air feed pipes leading to the starter. The R.H. upper covering cast strut houses the pipe feeding air to the barometric fuel control.

The C-300M starter with its fairing is secured to the flange of the central drive casing.

The compressor middle casing is used for mounting the stationary vanes and provides a robust connection between the front and rear casings of the compressor. The middle casing consists of the front compartment (M-7-5 magnesium alloy) and rear compartment (A-7-5 aluminum alloy). Each compartment is split along the horizontal and vertical planes. The flanges at the joints between the compartments are provided with ports for bypassing air from the compressor (blow-off ports). These ports are covered on the outside with a steel band which can be either pressed against the casing (closed position) or moved away from it (open position).

The air blow-off ports are opened and closed by the piston-type band control mechanism which is actuated by the engine automatic system.

Uniform circular gap between the blow-off band and the middle casing (in the open position) and elimination of band vibrations are ensured by the stops installed on the casing; these stops limit the movement of the band both in the longitudinal and radial directions.

The inner surface of the middle casing is provided with seven circular grooves receiving the webs of the stator vanes made of B1-17 aluminum alloy. The outer journals of the vanes are secured to the middle casing, whereas their inner journals are held together in each stage by two rigid half-rings which are split longitudinally. Each half-ring is fastened at the joint by studs. The outer surface of the compressor half-rings and discs form the inside contour of the compressor air-flow duct. The inner surface of the half-rings contact the cambered knife edges of the compressor vanes. The vanes are treated to reduce clearances in the labyrinth seals. The talcum compound is likewise applied to the inner surface of the middle

casing (on five bands facing the impellers of the first five stages), which brings to a minimum the radial clearances between the impellers and the compressor middle casing. Thus, talcum treatment ensures minimum flow of air from one stage into another, thereby minimizing the compressor hydraulic losses.

The compressor middle casing is provided with air-bleed flanges for the engine anti-icing system and for cabin pressurization; lugs for assembly fixtures; bosses for installing the engine wheelcase (top, right); accessory drive gearbox (top, left) and for other units and piping.

The middle casing is flange-connected to the front and rear casings of the compressor by means of fitted and plain bolts.

The rear casing of the compressor provides rigid structural connection between the compressor and the hot portion of the engine and serves as a mount for the two-row ball bearing (engine middle support and main engine-to-aircraft attachment fittings).

The rear casing is a welded structure made up of the combustion chamber casing, diffuser inner wall and the middle support cone.

The rear flange of the middle support cone is seam-welded to the inner wall of the diffuser, whereas the front flange is fastened by ten load-carrying struts to the inner ring of the compressor rear casing.

The annular duct formed by the combustion chamber casing band and the inner ring accommodates 80 stator vanes of the compressor 8th stage.

All the stator vanes are made of 3H-69 steel.

The annular duct after the stator vanes, formed by the diffuser inner wall and the combustion chamber casing is, essentially, a diffuser which delivers air into the combustion chamber. Secured to the inner ring of the compressor rear casing is the labyrinth which reduces the flow of air from the compressor air duct into the so-called rear pressure relief chamber.

Installed on the compressor rear casing are engine-to-aircraft mounting brackets and lifting brackets. There are also openings for installing the main burners and igniters, as well as air-bleed flanges for delivering air to the aircraft anti-icing system.

2. COMBUSTION CHAMBER

The engine features a cannular combustion chamber (Fig. 5) for burning the fuel and delivering the generated gases into the turbine. The flame tubes are arranged parallel with the engine axis in the circular space between combustion chamber casing 5 and turbine shaft shroud 9. The flame tubes are numbered in a counter-clockwise order, looking from the exhaust unit end, with the top left tube taken for No. 1 tube. The fuel is ignited in the flame tubes both on the ground and in flight by means of four igniters installed on flame tubes Nos. 3, 5, 10 and 12.

S-E-C-R-E-T

25X1

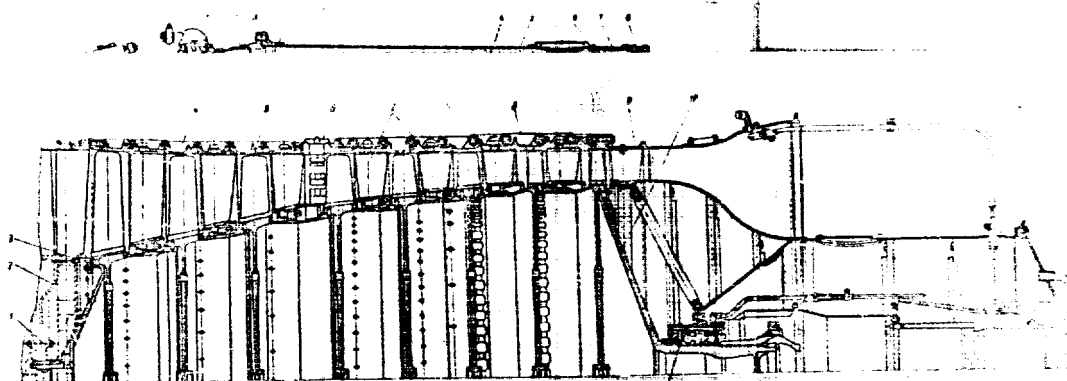


Fig. 4. Compressor.

The main burner (Fig. 6) is of the two-stage type. It has main flow nozzle channel 1 and primary nozzle channel 12 through which the fuel

A-E-C-R-E-T

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S-E-C-R-E-T

25X1

Attachment to

25X1

Extending through the R.H. lower strut of the front casing are the lower drive coupling shaft and the pipe for draining oil from the compressor front casing.

Located in the lower cast type covering struts are the following parts: in the L.H. strut — the pipe for scavenging oil from the lower oil collector (by the scavenge section of the starter oil pump) and the pipe feeding oil to the starter; in the R.H. strut — two pipes for draining fuel from the starter and the pipe for directing oil into the tank.

The pipe draining oil from the engine wheelcase is located in the R.H. horizontal strut of the front casing.

The L.H. horizontal strut of the front casing

casing (on five bands facing the impellers of the first five stages), which brings to a minimum the radial clearances between the impellers and the compressor middle casing. Thus, talcum treatment ensures minimum flow of air from one stage into another, thereby minimizing the compressor hydraulic losses.

The compressor middle casing is provided with: air-bleed flanges for the engine anti-icing system and for cabin pressurization; lugs for assembly fixtures; bosses for installing the engine wheelcase (top, right); accessory drive gearbox (top, left) and for other units and piping.

The middle casing is flange-connected to the front and rear casings of the compressor.

secured by the stops installed on the casing; these stops limit the movement of the band both in the longitudinal and radial directions.

The inner surface of the middle casing is provided with seven circular grooves receiving the webs of the stator vanes made of BA-17 aluminum alloy. The outer journals of the vanes are secured to the middle casing, whereas their inner journals are held together in each stage by two rigid half-rings which are split longitudinally. Each half-ring is fastened at the joint by studs. The outer surface of the compressor half-rings and discs form the inside contour of the compressor air-flow duct. The inner surface of the half-rings contacting the labyrinth knife edges of the compressor discs is talcum-treated to reduce clearances in the labyrinth seals. The talcum compound is likewise applied to the inner surface of the middle

the main burners and igniters, as well as air-bleed flanges for delivering air to the aircraft anti-icing system.

2. COMBUSTION CHAMBER

The engine features a cannular combustion chamber (Fig. 5) for burning the fuel and delivering the generated gases into the turbine. The flame tubes are arranged parallel with the engine axis in the circular space between combustion chamber casing 5 and turbine shaft shroud 2. The flame tubes are numbered in a counter-clockwise order, looking from the exhaust unit end, with the top left tube taken for No. 1 tube. The fuel is ignited in the flame tubes both on the ground and in flight by means of four igniters installed on flame tubes Nos. 3, 5, 10 and 12.

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The front flanges of the combustion chamber casing and turbine shaft shroud are fastened to compressor rear casing 3, whereas their rear flanges are attached to nozzle diaphragm assembly shroud 8. Being disconnected at the joints, the combustion chamber may be shifted freely towards the exhaust unit, thus allowing individual flame tubes to be inspected and replaced without disassembling the engine as a whole.

BXIII alloy for the same purpose. Being heated, each flame tube may expand freely towards the turbine.

Each flame tube consists of swirler 12, snout 11, finned liner 10, flame tube adapter 4, and shell 6.

Four flame tubes are provided with ignition ferrules 2 welded to the front outer surface of the liner; the rest of the tubes have bushings 17 for the retainers. The side surfaces of the liners are

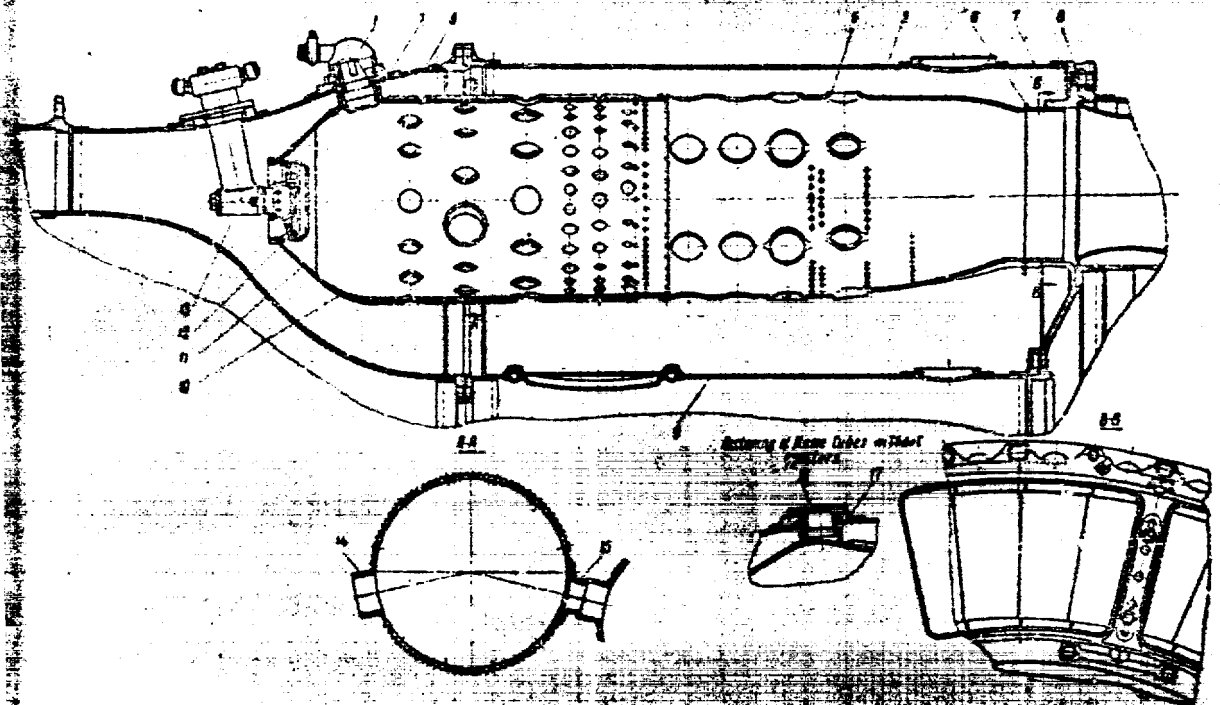


Fig. 3. Combustion Chamber.

1 - igniter, 2 - igniter ferrule, 3 - compressor rear casing, 4 - flame tube adapter, 5 - combustion chamber casing, 6 - shell, 7 - nozzle diaphragm assembly frame, 8 - nozzle diaphragm assembly shroud, 9 - turbine shaft shroud, 10 - liner, 11 - snout, 12 - swirler, 13 - main burner, 14, 15 - cross-fire tubes, 16 - retainers, 17 - retainer bushing.

Three hatches with doors located in the front part of the turbine shaft shroud give access to the coupling between the compressor and turbine shafts. The lower part of the combustion chamber casing is provided with two holes for draining fuel which may accumulate in the casing after engine stopping. The front ends of all the flame tubes rest on main burners 13, which are secured to the flange on the compressor rear casing; the rear ends of the tubes, the so-called shells 6 are telescoping in nozzle diaphragm assembly frame 7. Flame tubes Nos. 3, 5, 10 and 12 are secured axially by igniters 1; the rest of the tubes are held in place by retainers 16. Wear of the spherical retainer surfaces is reduced by chrome-plating, whereas the igniters are coated with fused-on

provided with welded cross-fire tubes 14 and 15 which are telescopically-jointed with the ferrules of the adjacent flame tubes which makes for penetration of fire into those flame tubes which have no igniters.

All the basic parts of the flame tubes are made of 3H-602 steel.

To reduce wear, the shell surface is copper-plated. Heat resistance of the flame tube is improved by coating it with 3B-300 enamel, except for the swirler.

The main burners supply fuel into the flame tubes.

The main burner (Fig. 6) is of the two-stage type. It has main flow nozzle channel 1 and primary nozzle channel 12 through which the fuel

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Attachment to

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flows, respectively, to main flow nozzle 20 and primary flow nozzle 23 located one after the other. While passing the tangential holes 21 into the swirler chamber of primary flow nozzle 23, the fuel is twisted up and enters the flame tube.

the primary nozzle. Provision of two swirler chambers ensures twisting of the fuel supplied from the main flow nozzle by the fuel flowing from the primary nozzle. This makes for satisfactory fuel atomization at the moment the main

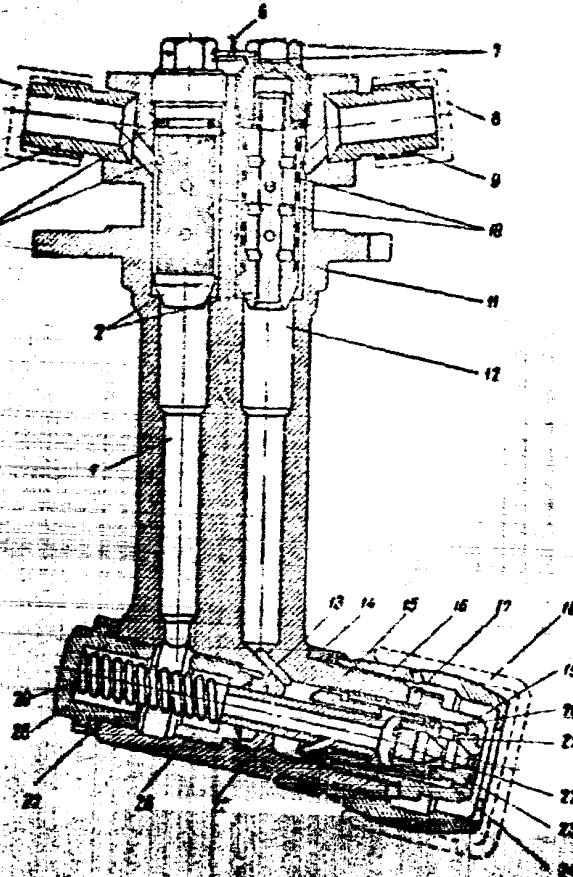


Fig. 2. Burner. 1 - main flow nozzle channel; 2 - sleeve; 3 - sealing ring; 4 - main manifold pipe union; 5 - plug; 6 - primary manifold pipe union; 7 - plug; 8 - primary flow nozzle channel; 9 - sealing ring; 10 - plug; 11 - sleeve; 12 - main flow nozzle; 13 - tangential hole in primary flow nozzle; 14 - plug; 15 - primary flow nozzle; 16 - tangential hole in main flow nozzle; 17 - plug; 18 - main flow nozzle; 19 - tangential hole in main flow nozzle; 20 - plug; 21 - spring; 22 - plug; 23 - plug; 24 - spring.

The primary stage of the burner delivers fuel at all the engine ratings, whereas the main flow stage starts operating when the pressure before the fuel pump distributing valve reaches 20-25 kg/cm² after which both stages operate jointly.

The swirler chambers of the primary and main flow nozzles are in communication with each other. The fuel enters the swirler chamber of main flow nozzle 20 through channel 1, and tangential holes 21 where it is twisted and directed into

flow nozzle starts operating. The main flow nozzle supplies fuel for the engine service ratings both on the ground and at low altitudes. The main burner consists of body 11 with soldered-in primary and main manifold pipe unions 5 and 4.

The fuel entering the burner is cleaned by filters 7 (filter screen 10) which are secured in the body by plugs 7 and sealing rings 3. Primary flow nozzle 23 and main flow nozzle 20 are secured in sleeve 19 by dividing pipe 25 and nut

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15. Sleeve 19 is screwed into the burner body and is fixed by lock-punched ring 17. Sleeve 16 slipped on the front end of the body receives the end of the flame tube. This sleeve has eight holes through which air is delivered to the nozzle in order to prevent formation of carbon on the face surface. The sleeve is locked with ring 14. Located in the rear part of the body are sealing ring 13, clamping bushing 26 (the latter being locked

Each turbine stage is formed by the nozzle diaphragm assembly and the impeller which is a steel disc with blades equispaced around its circumference.

The rear support of the turbine rotor is a roller bearing taking the radial stresses of the rotor. The axial stresses of the turbine rotor are transmitted by the spherical support to the compressor rotor, thus relieving the compressor ball

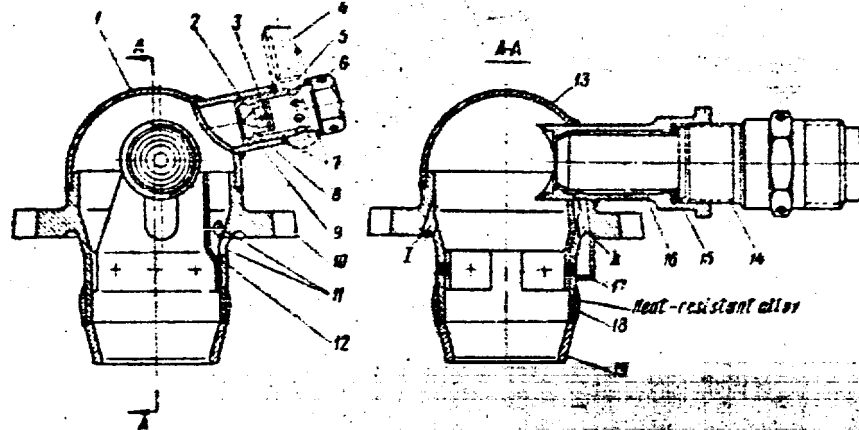


Fig. 7. Igniter.

1 - igniter body, 2 - pipe union, 3 - plug, 4 - fuel feed pipe, 5 - nipple, 6 - spray nozzle, 7 - gasket, 8 - atomizer, 9 - spray nozzle bushing, 10 - flange, 11 - air inlet hole, 12 - shield, 13 - spherical cover, 14 - spark plug, 15 - gasket, 16 - spark plug bushing, 17 - baffle, 18 - retainer, 19 - tip, 20 - low drain hole, 21 - air inlet hole

by spring 29), and plug 28 which is secured by lock-punched ring 27.

The igniter (Fig. 7) ignites fuel at engine starting. It consists of body 1, spray nozzle 6 and surface-discharge spark plug 14.

Igniter body 1 consists of the following parts: flange 10 with a retainer, spherical cover 13, shield 12, bushing 9, bushing 16, baffle 17 and tip 19. All these parts are made of IX18H9T steel. To reduce wear of the spherical surface of retainer 18, it is coated with heat-resistant alloy BXH1.

Spray nozzle 6 screwed into bushing 9 consists of pipe union 2, and atomizer 8 with plug 3. The starting fuel is fed to the burner through pipe 4 with nipple 5. Spark plug 14 is screwed into bushing 16.

All the joints are sealed with copper gaskets 7 and 15.

The air required for the formation of the combustible mixture is supplied into the igniter through holes 11.

The air directed by baffle 17 cools the face of spark plug 14 through air inlet hole 11.

3. TURBINE

The two-stage engine turbine of the impulse-reaction type (Fig. 8) develops the power required for rotating the compressor and the engine accessories.

bearings. The compressor spherical support makes up for possible misalignment of the compressor and turbine rotor axes.

The construction of the turbine provides for free access to the 2nd stage nozzle assembly for assembling and removing it with the turbine rotor installed and with the blades of the 2nd stage disc removed.

The turbine rotor consists of discs 10 and 17 with blades 14, torque-transmitting ring 19 and shaft 2 secured on which are the labyrinth, bushing, bearing race and the parts connecting the turbine rotor to the compressor rotor.

The rear end of the turbine rotor is supported by a roller bearing (engine rear support 6), while its front end with spherical support 1 rests on the two-row ball bearing (engine middle support).

The engine supports are connected by the shafting casings which separate the oil chambers from the high-pressure air chambers and protect the turbine shaft and the support bearings against being heated with air contained in the rear relief chamber of the engine.

Rotor discs 10 and 17, torque-transmitting ring 19 and turbine shaft 2 are interconnected by radial dowels 20 which transmit engine torque and retain centering of the interconnected parts when the latter are hot.

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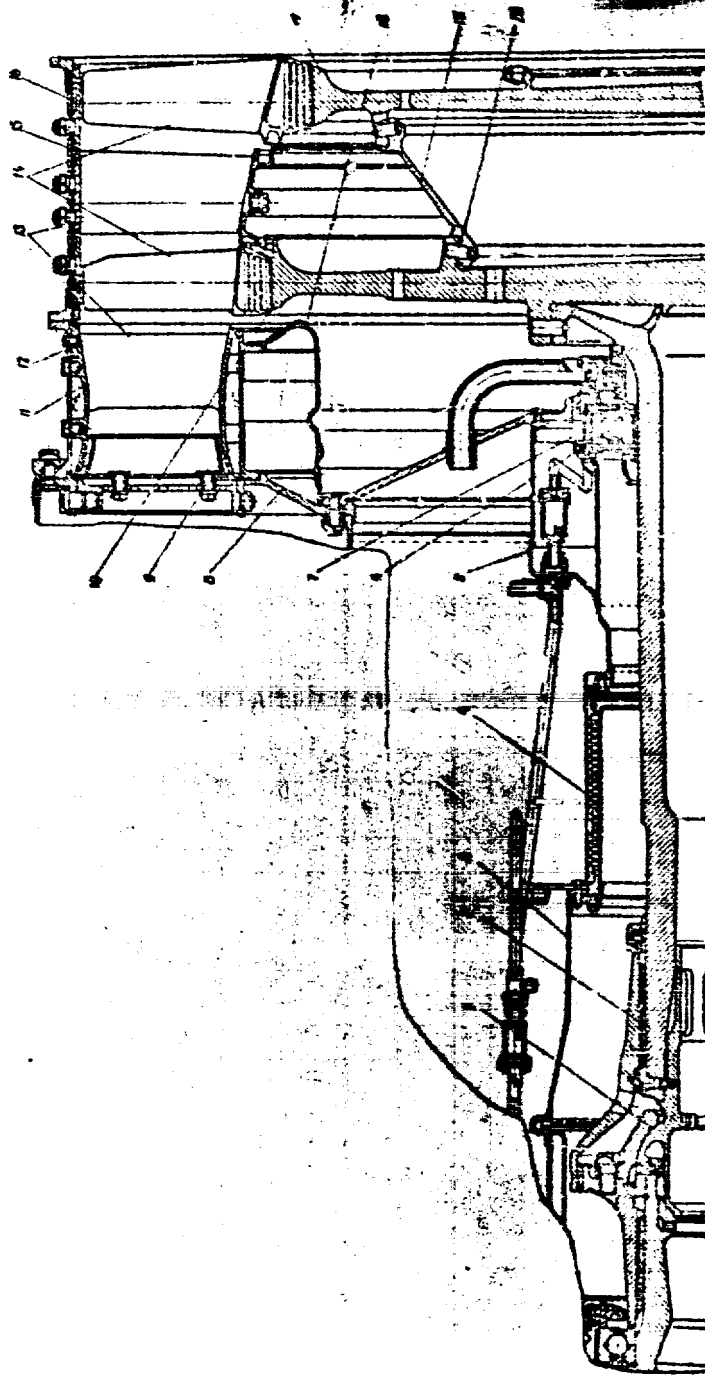


Fig. 8. Turbine:
1 - spherical support; 2 - turbine shaft; 3 - shafting casing; 4 - shafting middle casing; 5 - shafting end casing; 6 - nozzle diaphragm; 7 - nozzle diaphragm assembly; 8 - nozzle diaphragm assembly; 9 - nozzle diaphragm assembly; 10 - 1st stage turbine; 11 - 1st stage turbine; 12 - 1st stage turbine; 13 - 1st stage turbine; 14 - 1st stage turbine; 15 - 1st stage turbine; 16 - 1st stage turbine; 17 - 1st stage turbine; 18 - 1st stage turbine; 19 - 1st stage turbine; 20 - 1st stage turbine; 21 - 1st stage turbine; 22 - 1st stage turbine; 23 - 1st stage turbine; 24 - 1st stage turbine; 25 - 1st stage turbine; 26 - 1st stage turbine; 27 - 1st stage turbine; 28 - 1st stage turbine; 29 - 1st stage turbine; 30 - 1st stage turbine; 31 - 1st stage turbine; 32 - 1st stage turbine; 33 - 1st stage turbine; 34 - 1st stage turbine; 35 - 1st stage turbine; 36 - 1st stage turbine; 37 - 1st stage turbine; 38 - 1st stage turbine; 39 - 1st stage turbine; 40 - 1st stage turbine; 41 - 1st stage turbine; 42 - 1st stage turbine; 43 - 1st stage turbine; 44 - 1st stage turbine; 45 - 1st stage turbine; 46 - 1st stage turbine; 47 - 1st stage turbine; 48 - 1st stage turbine; 49 - 1st stage turbine; 50 - 1st stage turbine; 51 - 1st stage turbine; 52 - 1st stage turbine; 53 - 1st stage turbine; 54 - 1st stage turbine; 55 - 1st stage turbine; 56 - 1st stage turbine; 57 - 1st stage turbine; 58 - 1st stage turbine; 59 - 1st stage turbine; 60 - 1st stage turbine; 61 - 1st stage turbine; 62 - 1st stage turbine; 63 - 1st stage turbine; 64 - 1st stage turbine; 65 - 1st stage turbine; 66 - 1st stage turbine; 67 - 1st stage turbine; 68 - 1st stage turbine; 69 - 1st stage turbine; 70 - 1st stage turbine; 71 - 1st stage turbine; 72 - 1st stage turbine; 73 - 1st stage turbine; 74 - 1st stage turbine; 75 - 1st stage turbine; 76 - 1st stage turbine; 77 - 1st stage turbine; 78 - 1st stage turbine; 79 - 1st stage turbine; 80 - 1st stage turbine; 81 - 1st stage turbine; 82 - 1st stage turbine; 83 - 1st stage turbine; 84 - 1st stage turbine; 85 - 1st stage turbine; 86 - 1st stage turbine; 87 - 1st stage turbine; 88 - 1st stage turbine; 89 - 1st stage turbine; 90 - 1st stage turbine; 91 - 1st stage turbine; 92 - 1st stage turbine; 93 - 1st stage turbine; 94 - 1st stage turbine; 95 - 1st stage turbine; 96 - 1st stage turbine; 97 - 1st stage turbine; 98 - 1st stage turbine; 99 - 1st stage turbine; 100 - 1st stage turbine.

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The disc is upset with a spherical mandrel to prevent the dowels from falling out due to centrifugal forces.

The discs and the torque-transmitting ring are made from 3H431 steel, 1st stage turbine blades — from 3H617 and 2nd stage blades — from 3H437B material: the roots of the 2nd stage blades are of the four-tooth "fir-tree" shape and are fixed in the discs.

The 1st and 2nd stage blades are fixed longitudinally by plate locks, the wider ends of which are bent onto the disc and blade.

The 1st stage disc has a labyrinth projection below the bottom of the fir-tree groove, whereas the 2nd stage disc has two labyrinth projections.

The assembled turbine rotor is dynamically balanced by selecting the blades by weight, installing the prescribed number of balancing screws into the transportation shoulder of the 2nd stage disc and selecting these screws by weight and, finally, by removing some metal from the driving splined coupling.

The maximum permissible unbalance of the turbine rotor is 40 gcm.

The turbine rotor is connected with the compressor rotor by the splined coupling which transmits the turbine torque to the compressor. The splined coupling is located above the coupling of spherical support 1 which transmits axial stresses to the bearing. The coupling consists of the driving and driven splined members secured, respectively, on the splined ends of the turbine shaft and compressor rear hub.

The main components of the spherical supports are the spherical extension screwed all the way into the end of the turbine shaft, and the spherical support cover which contacts the spherical surface of the extension and is screwed rigidly to the driven member of the coupling.

The front end of the spherical extension has a second smaller surface which keeps the turbine rotor against displacement towards the compressor.

To connect the turbine and compressor rotors, shift the driving member of the coupling all the way towards the turbine and secure the spherical support cover to the driven member; then engage the driving member of the coupling with the splines of the driven member and prevent it from axial displacement by means of the fixing ring located on the extension of the coupling driving member.

The 1st stage nozzle diaphragm assembly consists of outer 12 and inner 9 shrouds, upper and lower shoes 11, vanes 13, frame 8 with fairings and shield 13.

The upper and lower shoes are fastened to the outer and inner shrouds, respectively, forming the outer and inner rings with sockets accommodating the nozzle assembly vanes which are cast of heat-resistant alloy ЖС-6К to withstand high thermal stresses in the engine.

The nozzle assembly frame is the main load-carrying element of the turbine, since it connects rigidly the outer and inner shrouds. The frame

consists of the outer and inner rings with interconnecting supports and is fastened to the combustion chamber casing, turbine shaft shroud and rear support housing.

The inner shroud of the nozzle diaphragm assembly is connected to the frame by the front flange. Fastened to the rear flange of the inner shroud is the shield which directs cooling air onto the 1st stage disc and the rear support housing.

The outer shoes and the nozzle assembly shroud are cooled with air forced through special milled recesses in the front flange of the outer shroud.

The front flange of the nozzle assembly outer shroud is secured to the combustion chamber casing and frame with bolts, part of which are of the fitted type.

Sixteen fitted bolts are longer than the other ones; they are used for fastening four aircraft mounting brackets (4 bolts per bracket).

The rear flange of the outer shroud is fastened to the shroud of the turbine 2nd stage nozzle diaphragm assembly.

The 2nd stage nozzle diaphragm assembly consists of shroud 16, shoes, band sections 15 and vanes 13 made of heat-resistant steel 3H437B. The shoes together with the front and rear labyrinth seals form a ring. Installed between the nozzle assembly shroud at one side and the band sections and vanes at the other are sheet steel spacers intended to reduce heating of the shroud.

Shafting Casings

The turbine shaft casing inside is divided by the shafting casings into two large chambers: the relief chamber between the turbine shaft casing and the shafting casings, and the oil chamber.

The oil chamber combines the oil chambers of the middle and rear supports with a view to simplifying the sealing system of the bearings and breathing. The inside space of the shafting casings is in communication with the atmosphere through the breathing pipe.

The shafting casings consist of three parts: shafting casing, middle casing and rear casing. The harmonica-type middle casing serves as a temperature compensating element ensuring freedom of movement for the shafting casings relative to the turbine shaft shroud. The shafting rear casing is provided with an oil receiver near the rear bearing. The rear casing is provided with three flanges for fastening the rear support oil feed and oil drain pipes, and the breathing pipe. The shafting casings are welded of sheet steel IX18H9T.

Rear Support

The rear support comprises the following parts and units: rear support housing, roller bearing, six oil jets delivering oil to the bearings, two of the jets have holes for feeding lubricant into the clearance between the bronze cage and

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race of the bearing), and two sealing covers with brass-coated knife edges working in conjunction with smooth bushings on the shaft. The roller bearing cage is lead-coated.

Turbine Cooling

To promote reliability of heated turbine parts, they are cooled with air. Cooling is provided (Fig. 9) for the turbine discs and the parts of

the 1st and 2nd stage nozzle diaphragm assemblies. The amount of the cooling air is equal approximately to 1-2% of the entire air flow through the engine; having cooled the turbine parts, the cooling air gets mixed with the main flow of gases. Cooling of the nozzle assembly parts allows the radial clearances in the turbine to be kept at a minimum at all the service ratings of the engine.

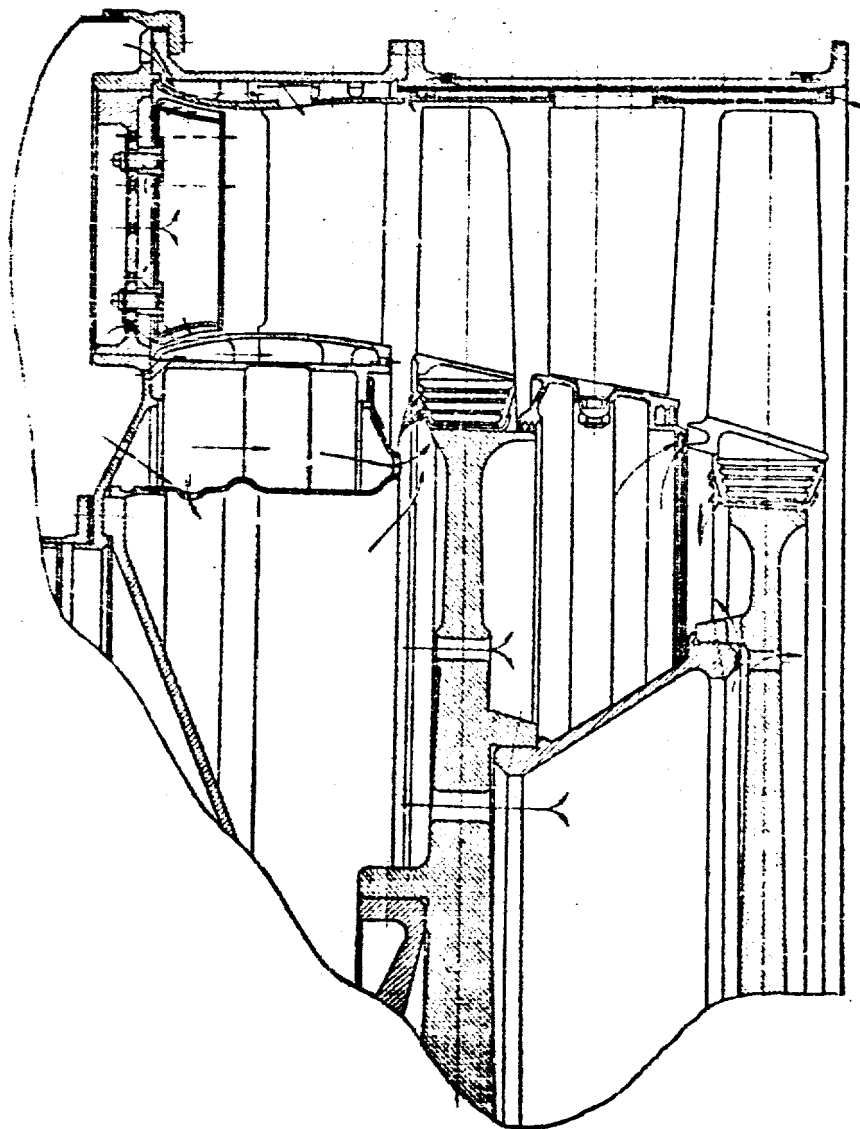


Fig. 9. Turbine Cooling System

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4. EXHAUST UNIT 25M-500

The exhaust unit (Fig. 10) converts the potential and kinetic energy of gases after the turbine into the reaction thrust of the engine.

The non-adjustable exhaust unit has no special provision for cooling.

The outlet cross-section area of the exhaust unit is adjusted during the acceptance trials by trimming or replacing the jet nozzles. The latter can be trimmed with the purpose of changing their outlet diameters from 640 to 861 mm.

temperature of gases after the turbine; six heat-insulating housings enclosing the fairing supports; and fifteen brackets for centering the exhaust unit aluminum housing. The pipe unions and heat-insulating housings are riveted to the outer wall, the brackets being seam-welded to it.

All the flanges of the outer and inner walls as well as the jet nozzle and the shield are made of 1X18H9T steel. The rest of the exhaust unit parts are of 3H-703 steel.

The aluminum housing which covers the exhaust unit and the turbine protects the parts of

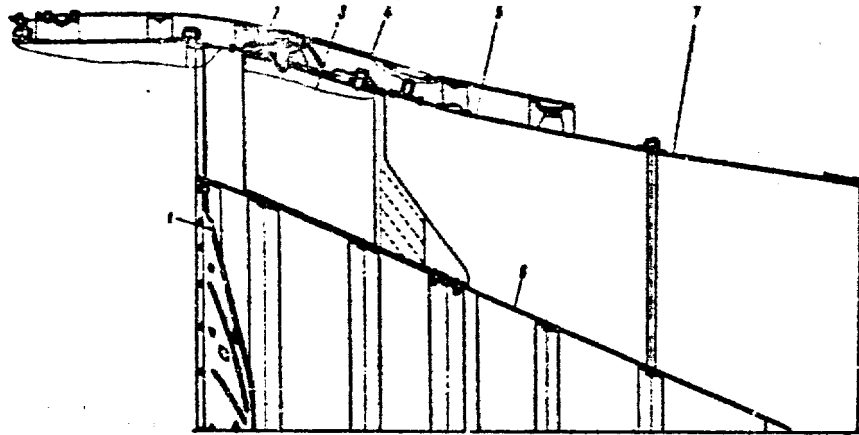


Fig. 10. Exhaust Unit

The exhaust unit consists, essentially, of the following components: outer wall 5, inner wall 6 with six fairings 3, jet nozzle 7, heat-insulating housings 2, shield 1 and exhaust unit housing 4.

The outer and inner walls, shield and jet nozzle are made of seam-welded sheet metal.

Rigidity of the outer and jet nozzle walls is improved by seam-welded bands. The inner wall is reinforced by five spot-welded bands.

The jet nozzle is bolted to the outer wall flange and forms, together with the outer and inner walls, the gas flow duct of the exhaust unit.

Six fairings equispaced around the circumference are seam-welded to the inner wall flanges being additionally secured with four bolts each. Attachment of the fairings to the outer wall of the exhaust unit is done by means of radial bolts which fit telescopically into the nitrated bushings pressed into the holes of the bosses which are welded to the fairings.

The bolts are screwed into the threaded holes of the supports welded to the outer wall of the exhaust unit. This type of joint makes up for different degrees of heat expansion of the inside and outside parts of the exhaust unit.

In addition to the fairing supports, the outer wall of the exhaust unit is provided with four pipe unions for the thermocouples measuring the

the aircraft against heating. The housing is fastened to the front flange of the 2nd stage nozzle assembly shroud by means of fourteen brackets and supports. Centering of the housing on the exhaust unit is ensured with the help of 15 brackets.

5. DIAGRAM OF ENGINE MECHANISM

The diagram showing transmission of torque from the compressor rotor to the engine-mounted accessories appears in Fig. 11

1. From driving shaft 3 of the central drive, through bevel gears and coupling shafts 2 and 4 the torque is transmitted to R.H. 5 and L.H. 7 intermediate drives and thence, through coupling shafts 11, to engine wheelcase 10 and accessory drive gearbox 13.

2. From driving shaft 3 through bevel gears and coupling shaft 21 the torque is transmitted to lower drive 25.

3. During engine starting the torque is transmitted from the C-300M starter to the engine rotor through the driving shaft.

The driven units, their location, rotation, and transmission ratios are given in the Table below.

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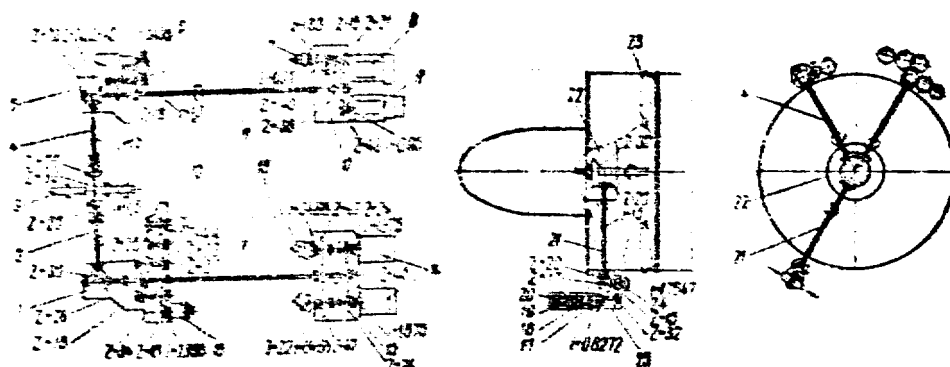


Fig. 11 P-3M 500 Engine. Diagram of Mechanism.

1 - LH intermediate drive; 2 - LH intermediate drive coupling shaft; 3 - central drive driving shaft; 4 - RH intermediate drive; 5 - LH intermediate drive coupling shaft; 6 - LH intermediate drive coupling shaft; 7 - LH intermediate drive coupling shaft; 8 - LH intermediate drive coupling shaft; 9 - LH intermediate drive coupling shaft; 10 - LH intermediate drive coupling shaft; 11 - LH intermediate drive coupling shaft; 12 - LH intermediate drive coupling shaft; 13 - LH intermediate drive coupling shaft; 14 - LH intermediate drive coupling shaft; 15 - LH intermediate drive coupling shaft; 16 - LH intermediate drive coupling shaft; 17 - LH intermediate drive coupling shaft; 18 - LH intermediate drive coupling shaft; 19 - LH intermediate drive coupling shaft; 20 - LH intermediate drive coupling shaft; 21 - LH intermediate drive coupling shaft; 22 - LH intermediate drive coupling shaft; 23 - LH intermediate drive coupling shaft; 24 - LH intermediate drive coupling shaft; 25 - LH intermediate drive coupling shaft.

Name of Link or Drive	Transmission ratio, from compressor rotor to driven unit or drive	Direction of rotation	Point of installation
Left LH intermediate drive coupling shaft	$i = \frac{31}{23} \cdot \frac{20}{17} = -1.7617$	RH	lower drive
Drive to pump and scavenging pump	$i = \frac{31}{23} \cdot \frac{20}{17} \cdot \frac{15}{11} = -0.8272$ (all stages)	LH (left stages)	do
Drive to compressor front casing air filter support	$i = \frac{30}{25} \cdot \frac{20}{17} \cdot \frac{15}{11} = -0.8272$	LH	do
Drive to centrifugal heater	$i = \frac{30}{25} \cdot \frac{20}{17} \cdot \frac{15}{11} = -1.938$	RH	LH intermediate drive
Drive to ITS 2 tachometer generator	$i = \frac{30}{25} \cdot \frac{20}{17} \cdot \frac{15}{11} = -0.5$	RH	do
Drive to ITS 2 tachometer generator	$i = \frac{30}{25} \cdot \frac{20}{17} \cdot \frac{15}{11} = -0.5$	LH	do
Drive to 2000 RPM generator	$i = \frac{31}{23} \cdot \frac{20}{17} \cdot \frac{15}{11} = -1.875$	LH	a/c accessory drive gearbox
Drive to 2000 RPM generator	$i = \frac{31}{23} \cdot \frac{20}{17} \cdot \frac{15}{11} = -1.875$	LH	do
Drive to 2000 RPM generator	$i = \frac{30}{25} \cdot \frac{20}{17} \cdot \frac{15}{11} = -0.468$	RH	do
Drive to 2000 RPM generator	$i = \frac{30}{25} \cdot \frac{20}{17} \cdot \frac{15}{11} = -0.468$	RH	do
Drive to 2000 RPM generator	$i = \frac{30}{25} \cdot \frac{20}{17} \cdot \frac{15}{11} = -0.428$	RH	RH intermediate drive
Drive to 2000 RPM generator	$i = \frac{31}{23} \cdot \frac{20}{17} \cdot \frac{15}{11} = -0.25$	LH	engine wheelcase
Drive to 2000 RPM generator	$i = \frac{30}{25} \cdot \frac{20}{17} \cdot \frac{15}{11} = -0.25$	LH	do
Drive to 2000 RPM generator	$i = \frac{30}{25} \cdot \frac{20}{17} \cdot \frac{15}{11} = -1.22$	LH	do

View from the rear of an observer looking at the drive from the unit
View from the front of an observer looking at the unit drive from the shaft extension side

S-E-C-R-E-T

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6. ENGINE LUBRICATING SYSTEM

This system provides constant oil supply to the working surfaces with a view to reduce friction and transferring heat from them. In addition, it collects and by scavenging section 10 from the lower drive.

The oil scavenged by the three sections is directed into the oil tank through a single pipe and the fuel oil cooler installed on the aircraft.

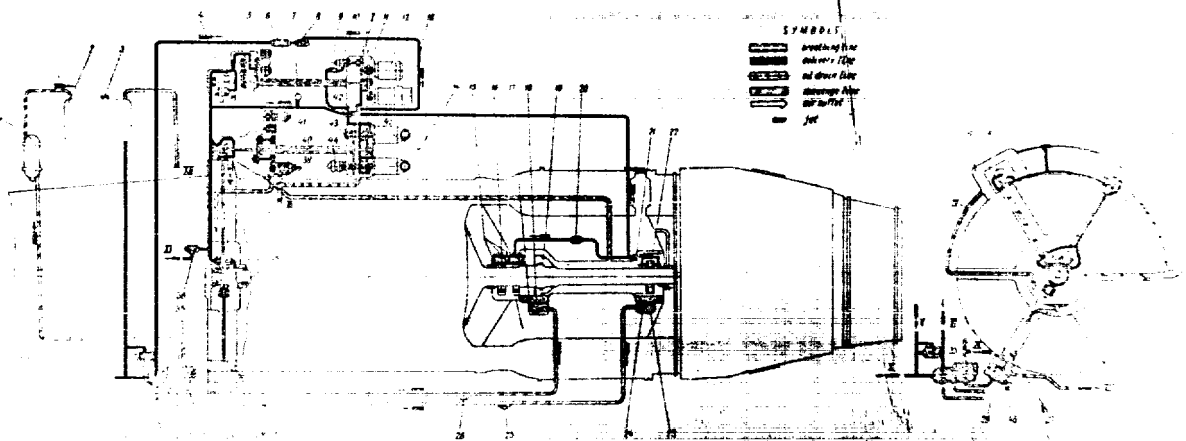


Fig. 12 Engine Lubricating Diagram

1 - Fuel oil cooler; 2 - Fuel oil pump; 3 - Fuel oil filter; 4 - Fuel oil line; 5 - Fuel oil line; 6 - Fuel oil line; 7 - Fuel oil line; 8 - Fuel oil line; 9 - Fuel oil line; 10 - Fuel oil line; 11 - Fuel oil line; 12 - Fuel oil line; 13 - Fuel oil line; 14 - Fuel oil line; 15 - Fuel oil line; 16 - Fuel oil line; 17 - Fuel oil line.

NOTE: The lens in this diagram is to be set for all copying.

S-E-C-R-E-T

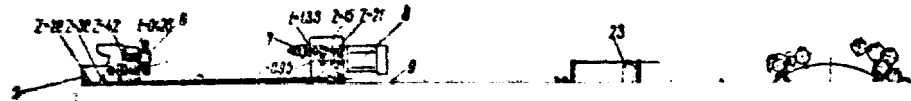
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- 2-100

1 - L.H.
coupling
2 - T.H.
pump
3 - mid
shaft
23

Name

UH-1H center

Drive to oil
pumps:

- a) from C
- b) from M
- c) from R

Drive to oil

Drive to car

Drive to H

Drive to H

GCP-16000M

GCP-16000M

GCP-16000M

GCP-16000M

GCP-16000M

GCP-16000M

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S-E-C-R-E-T

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6. ENGINE LUBRICATING SYSTEM

This system provides constant oil supply to the working surfaces with a view to reducing friction and transferring heat from them. In addition, the oil entrains the particles of worn metal, carrying them away from the friction surfaces.

The lubricating system comprises the following components:

oil tank, fuel oil cooler; oil pump unit, oil filters; return valve; centrifugal breather; pipes, channels; and oil jets feeding oil to the points of lubrication.

Operation of the lubricating system is shown in Fig. 12.

The engine is fitted with forced-circulation system of lubrication.

The oil is taken from aircraft-mounted oil tank 1 and fed to delivery section 33 of the oil pump unit from which it moves into second stage oil filter 6. Further, the oil flows from the filter through return valve 3 and a channel into engine wheelcase 11 and oil distributing unit 42.

The oil distributing unit delivers oil through pipes to the following points:

1) Through additional filters 20 and 21 to the bearings of engine rotor middle 16 and rear 22 supports.

2) To R.H. intermediate drive 1.

3) To L.H. intermediate drive and, through the channel in the drive and through the pipe located in the L.H. cast strut of the compressor front casing, to central drive, idle starter and further through an auxiliary filter to the bearing of engine rotor front support 38.

4) To accessory drive gearbox 43.

5) Through auxiliary filter 9 to centrifugal transmitter 10 for lubrication of the transmitter and for exerting hydraulic pressure upon the membrane of the transmitter electric microswitch.

The pressure of oil in the delivery line is maintained by two-stage pressure control valve 34 of the oil pump unit. At an engine rating of 0.8 nominal and higher, this pressure ranges from 3.5 to 4.5 kg/cm^2 , while at 800—1200 r.p.m. (speed of autorotation) the delivery line pressure is kept not over 2.9 kg/cm^2 , which ensures normal lubrication of the working surfaces at this rating.

The oil pressure in the delivery line is measured by electric remote-mounted pressure gauge 7 whose pick-up unit is connected to the pipe union located on the pipe feeding oil to the intermediate drives. The engine inlet oil temperature is measured by an electric resistance thermometer whose pick-up unit 45 is located in the oil distributing unit.

Used oil is drained from the intermediate drives, engine wheelcase and accessory drive gearbox, as well as from the central drive and front support into the housing of lower drive 29.

The oil which has lubricated the middle and rear bearings of the engine rotor drains into two oil collectors 17 and 23 of the shafting casings.

Scavenging of oil is ensured by scavenging sections 32 and 31 of oil pump unit 35 from the

oil collectors and by scavenging section 30 from the lower drive.

The oil scavenged by the three sections is directed into the oil tank through a single pipe and the fuel oil cooler installed on the aircraft.

The engine has three oil drain points: oil drain cock 46 on the lower drive and oil drain plugs 25 and 26 located on the pipes through which oil is scavenged from the shafting casings.

The engine supports are lubricated through oil jets: the front support through 1-mm dia. jet, the middle support — through twelve 1-mm dia. jets and the rear support — through two 0.7-mm dia. jets and six 1-mm dia. jets.

Leakage of oil from the engine supports and shafting casings is prevented by labyrinth seals installed at the pressure chamber sides. The rear support labyrinth is of the two-stage type, with a relief chamber intended to reduce the pressure and amount of air entering the bearings through the labyrinth.

The hot gases penetrating past the rear labyrinth are discharged through a pipe into the space between the turbine shaft shroud and the shafting casing and then, through the pressure relief pipes — into the atmosphere. The pressure in the relief chamber is from 0.3 to 0.55 atm.

During cold cranking of the engine and unsuccessful startings, lower drive 29 becomes filled with oil which is then transferred by the scavange section of the starter two-section oil pump into the pipe through which the oil is discharged into the fuel oil cooler.

Lubrication of accessory drives. The bevel gears of the intermediate drives as well as the splined joints of the coupling shafts which transmit rotation to the engine wheelcase and accessory drive gearbox are lubricated under pressure through oil jets. The central drive bevel gears are likewise lubricated through oil jets. The intermediate and central drive bearings, intermediate drive spur gears, as well as the lower drive are lubricated by splashing. The used oil is drained from the intermediate drives into the oil collector of the compressor front casing through the inner spaces of the compressor front casing upper struts.

The generator drive gears, the ball bearings the generator and hydraulic pump drives, the splined joint of the accessory drive gearbox coupling shaft, the fuel pump drive gears and the splined joint of the engine wheelcase coupling shaft are pressure-lubricated through oil jets. The rest of the gears and bearings in the engine wheelcase and accessory drive gearbox are splash-lubricated. The oil used in the engine wheelcase and accessory drive gearbox is drained through pipes extending longitudinally outside the engine and through the R.H. and L.H. horizontal cast struts of the compressor front casing. The oil delivered to the centrifugal transmitter lubricates its parts and, in addition, exerts hydraulic pressure on the electrical microswitch K-5.

S-E-C-R-E-T

Filter 9 is installed at the centrifugal transmitter oil inlet. Oil from the transmitter is drained into the engine wheelcase.

Engine breathing contributes to normal functioning of the lubricating system. The vented spaces of the compressor front casing and the shafting casing are in communication with the atmosphere through the centrifugal breather. These spaces communicate with the centrifugal breather

The shafting casing chamber communicates with the tachometer drive body through the external pipe, extending longitudinally on the LH side of the engine.

Being cleaned of oil particles in the breather, the air is discharged through the pipe into the atmosphere while the oil is drained from the breather together with the oil from the accessory.

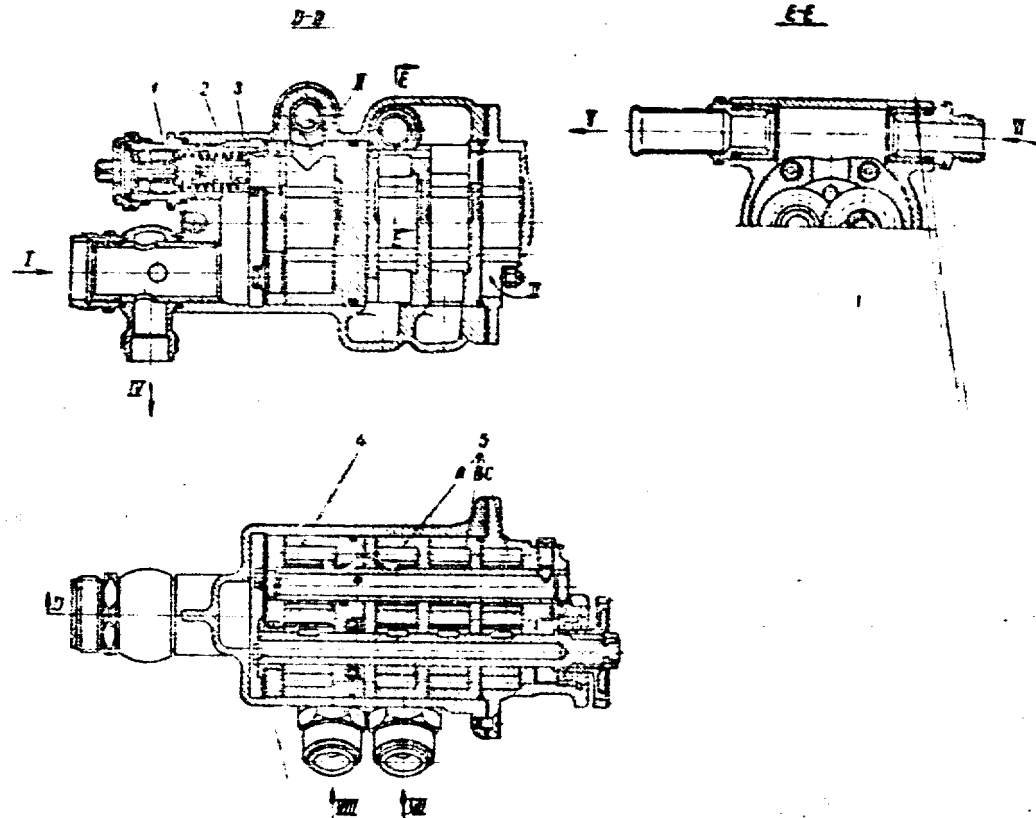


Fig. 13. Oil Pump Unit

1 - pressure control valve; 2 - valve 1st stage; 3 - valve 2nd stage; 4 - delivery section; 5 - delivery section of inlet; 6 - delivery section of outlet; VII - "C" section of inlet; IV - oil into delivery section of inlet; V - waveless section of outlet; VI - oil from starter oil pump assembly section; VII - "B" section of inlet; VIII - "A" section of inlet

*A) section scavenges oil from rear support
B) section scavenges oil from middle supports
C) section scavenges oil from lower drive

mounted on the L.H. intermediate drive through the chamber of the tachometer drive body. The oil tank is vented to the atmosphere through the compressor front casing. The inside space of the compressor front casing communicates with the tachometer drive body through the pipe extending through the L.H. upper cast strut of the compressor front casing and through the external breath intake pipe. The external pipe connects the oil tank with the L.H. horizontal cast strut of the compressor front casing.

drive gearbox into the oil collector of the compressor front casing

The oil pressure and temperature measurements ensuring proper control of lubrication are taken by the 3MI 3P instrument. Oil pressure gauge pick-up unit 7 is connected to the pipe union on the pipe feeding oil into the intermediate drives. Inlet oil temperature pick-up unit 45 is installed in the oil distributing unit.

Lubricating system units. The oil pump unit (Fig. 13) consists of a delivery section and three

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scavenge sections enclosed in a single body. The gear-type oil pump unit provides for necessary circulation of oil in the engine lubricating system.

The oil pump unit is provided with two-stage pressure control valve 1. The 1st stage 2 of the valve maintains an oil pressure not exceeding 0.9 kg/cm^2 at the autorotation rating. The 2nd stage 3 provides for a constant oil pressure in the system at all the service ratings of the engine.

The oil filter (Fig. 14) is used for fine cleaning of oil at the engine inlet and consists of 19-21 filtering sections 1 clamped together by a frame.

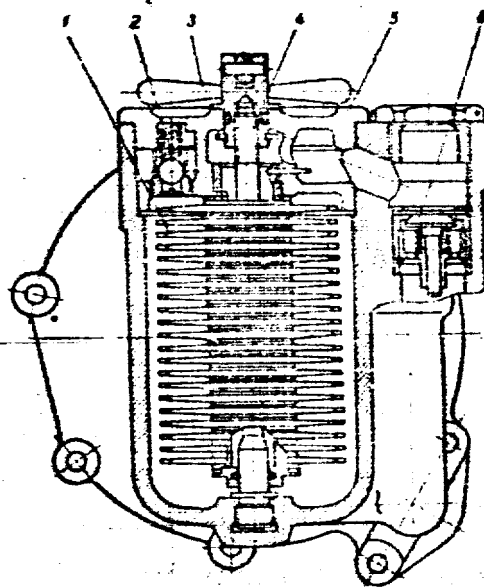


Fig. 14 Oil Filter

1 - filter section, 2 - ball safety valve, 3 - handle, 4 - center rod, 5 - cover, 6 - return valve

The filter is fitted with ball safety valve 2 which can pass oil into the engine past the filter sections, should they become clogged, and with return valve 6 preventing the oil from flowing from the oil tank into the engine when the latter is not running.

The set of filter sections is easily removable. Rotating handle 3 counter-clockwise it is possible to screw it off center rod 4 after which the set of filter sections together with cover 5 can be lifted out of the filter casing.

The centrifugal breather (Fig. 15) separates oil from the air-oil mixture created in the shafting and compressor front casings due to splashing of oil by the rotating parts.

Saturated with oil fumes, the air enters impeller 2 through four holes 4 at the side of the breather attachment flange.

The oil is thrown by the centrifugal force onto the inner surface of the casing, the latter is provid-

ed with oil-collecting groove 7 through which the oil is forced into groove 6.

From here the oil is drained into the compressor front casing through the pipe union on breather body 5 and a pipe.

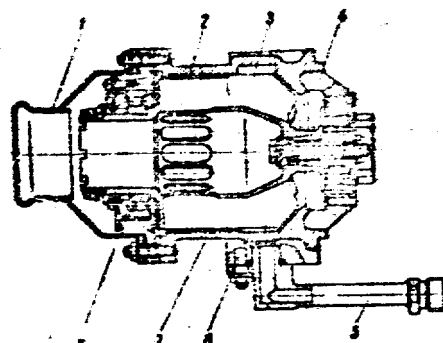


Fig. 15 Centrifugal Breather

1 - outlet pipe, 2 - impeller, 3 - impeller, 4 - hole, 5 - breather body, 6 - groove, 7 - oil-collecting groove, 8 - centrifugal breather housing

Being cleaned of oil, the air flows through the hole in the hub of impeller 2 into breather housing 8 and further into outlet pipe 1.

7. ENGINE FUEL SYSTEM

The engine fuel system (Fig. 16) delivers fuel into the combustion chamber in quantities sufficient for starting and service operation of the engine at the given ratings.

The system comprises three separate systems each having its specific function: starting fuel system, main fuel system, and drainage system.

Starting Fuel System

The starting fuel system delivers fuel for firing up the engine combustion chamber at starting only within the range of engine rotor speeds from 250 ± 30 to $810 \pm 70 \text{ r.p.m.}$

The starting fuel system comprises aircraft-mounted starting fuel tank 26, filter 27, starting fuel pump 28 (electric-driven gear type), electromagnetic valve 29, starting fuel manifold 30 with four filters 31 fitted with return valves, and four igniters 32 with starting burners and spark plugs.

During engine starting the C-300M gas turbine starter accelerates the engine rotor and when the speed of the latter reaches $250 \pm 30 \text{ r.p.m.}$, the H.T. current is automatically supplied to the engine spark plugs; simultaneously the starting fuel pump motor and the electromagnetic valve are turned on; in this manner the starting fuel system delivers fuel for firing up the engine combustion chamber.

As soon as the combustion chamber operates under its own power and the engine rotor speed reaches 810 ± 70 r.p.m., the H.T. current is automatically cut off from the spark plugs; simultaneously the starting fuel pump motor and the electromagnetic valve are turned off; this marks the end of starting fuel system operation.

Main Fuel System

The main fuel system delivers fuel into the engine combustion chamber beginning from the speed when the fuel starts to be fed to the first stages of the two-stage main burners and until the emergency rating speed is attained. (The

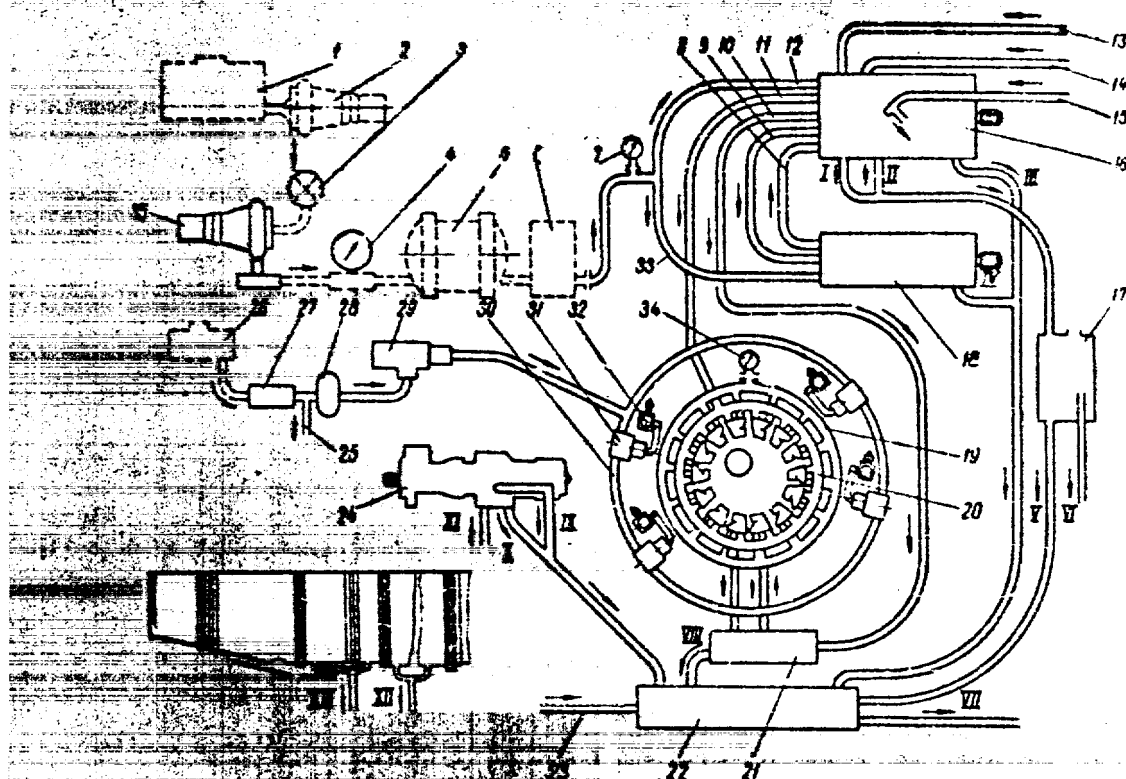


Fig. 16 Engine Fuel System.

1 - main fuel tank, 2 - fuel pump, 3 - fuel control valve, 4 - flow meter, 5 - fuel oil cooler, 6 - screen filter, 7 - fuel pressure indicator, 8 - fuel pump throttle valve, 9 - fuel pump distributing valve, 10 - fuel from fuel pump distributing valve to primary fuel manifold, 11 - fuel from fuel pump distributing valve to main fuel manifold, 12 - fuel from fuel pump distributing valve to engine compressor, 13 - fuel from fuel pump distributing valve to starting fuel control unit, 14 - fuel from fuel pump distributing valve to drain tank, 15 - fuel from fuel pump distributing valve to C-300M gas turbine starter, 16 - fuel from fuel pump distributing valve to starting fuel pump, 17 - fuel from fuel pump distributing valve to electromagnetic valve, 18 - fuel from fuel pump distributing valve to starting fuel manifold, 19 - fuel from fuel pump distributing valve to fuel boost pump, 20 - fuel from fuel pump distributing valve to fuel control unit drain, 21 - fuel from fuel pump distributing valve to starting fuel control unit drain, 22 - fuel from fuel pump distributing valve to drain from chamber between fuel pump glands, 23 - fuel from fuel pump distributing valve to drain from chamber between fuel pump glands, 24 - fuel from fuel pump distributing valve to drain from burner fuel manifolds, 25 - fuel from fuel pump distributing valve to fuel drain from C-300M starter fuel regulating pump, 26 - fuel from fuel pump distributing valve to fuel drain from combustion chamber casing of C-300M starter, 27 - fuel from fuel pump distributing valve to fuel drain from engine combustion chamber casing.

Note: Vents and drains shown in dotted lines are installed by the Aircraft Plant.

The starting burners supply fuel into the igniters of the engine combustion chamber.

The electromagnetic valve denies access of gases from the engine combustion chamber into the starting fuel pump during engine operation and keeps the starting fuel against flowing into the inoperative engine along the gaps between the starting fuel pump gears.

start-of-fuel-feed engine speed is set by the distributing valve of the fuel pump and varies from 250 to 350 r.p.m.).

The main fuel system comprises such aircraft-mounted components as main fuel tank 1, fuel boost pump 2, fuel shut-off valve 3, flow meter 4, fuel-oil cooler 5, and screen filter 6, besides, there are such engine-mounted units as fuel boost pump

35, fuel pump 14 (PH-28B) and 16 (PH-15B), primary fuel manifold 19 and main fuel manifold 20, fourteen main burners, drain valve 21, flow-off tank 17, and drain tank 22.

The electric remote pressure gauges mounted on the aircraft are used to measure two kinds of fuel pressure in the main fuel system, namely, at the fuel pump inlet (pressure indicator 7) and in the burner primary manifold (pressure indicator 34).

Main fuel manifold 20 is supplied with fuel through the pipe union located at the uppermost point of the manifold, whereas drainage is effected through the lower pipe union. Primary fuel manifold 19 is supplied with fuel through drain valve 21 to the lower pipe union; drainage of fuel after engine stopping is effected through the same pipe union.

The primary manifold of the burners delivers main fuel to the primary nozzle channels of the main burners, whereas the main fuel manifold delivers fuel to their main flow nozzles.

The main burners deliver adequately atomized fuel into the engine combustion chamber.

Fuel pumps 13 (PH-28B) and 16 (PH-15B) supply the engine combustion chambers with fuel in quantities required for maintaining the predetermined speeds of the engine rotor.

Both pumps operate jointly.

The PH-28B fuel pump consists of a high-pressure plunger pump, a centrifugal variable-speed governor, a throttle valve and a hydraulic decelerator.

The PH-15B fuel pump consists of a high-pressure plunger pump, a barometric fuel control unit, an acceleration control unit, a minimum pressure valve, a distributing valve and an automatic starter with a barometric control unit.

The high-pressure plunger pumps of the PH-28B and PH-15B fuel pumps supply fuel into the engine combustion chamber. The amount of fuel fed at each particular speed of the engine depends on the angle of the wobble plates.

The barometric fuel control unit changes the fuel feed (by changing the angle of the PH-15B pump wobble plate) to suit the altitude and speed of flight.

Had there been no barometric fuel control unit the PH-15B fuel pump alone would have supplied more fuel at high altitude than is required by the engine so that the PH-28B pump would have to operate within a wide range of ratings under adverse conditions, i.e. in the capacity of a scavenging pump.

The centrifugal variable speed governor and the barometric fuel control unit of the PH-15B pump ensure at each steady engine rating an actually constant speed of the engine rotor irrespective of the flying altitude and speed (the governor starts operating when the engine rotor speed exceeds the speed set for beginning of automatic control).

When the speed of the engine rotor is lower than necessary for the beginning of automatic control, the centrifugal governor and the throttle

valve constant pressure differential valve maintain a constant pressure differential before and after the throttle valve (by retaining a certain predetermined angle of the PH-28B pump wobble plate), which, with the throttle valve in the unchanged position, ensures constant fuel delivery and consumption and constant engine rotor speed under the given flying conditions.

The throttle valve is intended for emergency manual control of fuel feed into the engine combustion chamber if the rotor R.P.M. automatic control system fails.

The distributing valve regulates the supply of fuel into the combustion chamber depending on the fuel pressure before it (after the PH-28B and PH-15B fuel pumps).

The automatic starter with the barometric fuel control unit regulates the supply of fuel into the engine combustion chamber depending on the air pressure after the engine compressor when the engine is being started both on the ground and in flight.

The hydraulic decelerator and the acceleration control unit regulate the supply of fuel into the engine combustion chamber when the engine rating is sharply changed from idling speed to emergency rating speed or to any of the intermediate speeds at any shifting speeds of the PH-28B pump control lever at any flying altitudes and speeds.

The minimum pressure valve limits the decrease in the fuel supply (by limiting the fuel pressure drop before the main burners) into the combustion chamber when the engine rating is sharply changed from the maximum or any of the intermediate speeds down to the idling rating; the fuel supply is limited to such a level which prevents the combustion chamber from stalling at any shifting speed of the PH-28B pump control lever at any flying altitudes and speeds.

Drainage System

As its name implies, this system provides for drainage of the fuel from the points of its accumulation in the engine, and of the fuel which seeps through the gaps into the drainage chambers of the engine fuel system units.

Drain tank 22 located under the engine collects fuel from the primary and main fuel manifolds when the engine is stopped from the space between the glands of the PH-28B and PH-15B fuel pumps, centrifugal governor of the C-300M gas turbine regulating fuel pump, and from the fuel system of the C-300M gas turbine starter at the time it is being started.

The drain tank is emptied by compressed air which is forced into the tank from after the last stage of the engine compressor and which blows the fuel out beyond the edge of the exhaust unit jet nozzle.

Draining of the main fuel from the burner manifolds is necessary in order to prevent afterburning of the fuel in the stopped engine; drainage is effected automatically by drain valve 21.

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The fuel system of the gas turbine starter is drained automatically by the relief valve.

The fuel from the automatic starting unit and the IHH-155 pump barometric fuel control unit is drained into flow-off tank 17 which is vented to the atmosphere; the fuel from these units cannot be drained into tank 22 because the compressed air fed into it would affect adversely the operation of the automatic starting unit and barometric fuel control unit.

On the running engine, the fuel is discharged from flow-off tank 17 through pipe V1 beyond the edge of the exhaust unit jet nozzle. Flow-off tank 17 communicates with drain tank 22 through pipe V whose jet inside diameter is 0.8 mm; through this the fuel is drained after stopping the engine. On the running engine the fuel is prevented from draining through pipe V by the air compressed in the drain tank.

Drainage of fuel into the atmosphere is effected separately from the casing of the C-300M starter combustion chamber, engine combustion chamber casing, and from the engine turbine nozzle diaphragm assemblies.

8. ELECTRICAL EQUIPMENT

The electrical equipment of the engine includes the power sources for supply of the aircraft and engine current-consuming units, the units for starting the engine and the units controlling the compressor air blow-off system and the emergency rating system.

Power Sources

The basic sources of electric power are two D.C. 18,000-W generators, Model TCP-18000M, installed on the aircraft accessory drive gearbox.

Each generator works in conjunction with type P5T-82 carbon voltage regulator, DMP-600AM differential minimum relay, DC-15000 ballast resistor and TC-9M voltage-stabilizing transformer.

The above equipment is mounted on the aircraft and serves to maintain a constant voltage at varying engine speeds; it prevents the flow of reverse current into the generator on the stopped and idling engine thereby protecting the aircraft storage batteries against discharge; it provides for parallel operation of the generators; and reduces the range and time of voltage variations at changes of engine ratings.

Electrical Starting Units

To these belong the engine and starter ignition circuit KPH4-2P1 low-tension booster coil, the KPH-21 booster coil, four surface-discharge spark plugs CIH-4-3 and two CI-55AHM spark plugs, engine fuel system units (starting unit, model M-102A, and the electromagnetic fuel valves), C-300M starter electrical units, 2 electric mechanism, pneumatic contactor, 1 electric starting electric motor, and two electro-

magnetic fuel valves), and the units controlling the entire process of engine starting (tachometer generator TD-1 and relay box IT-4B).

The booster coil units KPH4-2P1 and the KPH-21 booster coil of the vibrating type are intended to supply H. T. current to six spark plugs of which four CIH-4-3 spark plugs are installed on the engine and two CI-55AHM spark plugs — on the C-300M gas turbine starter.

The booster coil units KPH4-2P1 are mounted in the lower part of the engine (two on each side of the engine) and supply four CIH-4-3 spark plugs.

The KPH-21 booster coil is installed on the C-300M starter for supplying two spark plugs of the latter. The H. T. wires leading to the spark plugs are efficiently shielded.

The CIH-4-3 spark plugs are of the one-piece, shielded, surface-discharge type with ceramic insulation whereas the CI-55AHM spark plugs are of the one-piece, shielded type with central electrodes; both types of spark plugs are component parts of the engine and starter igniters used to ignite the fuel.

The electric motor, model M-102A, is a series-excited machine in an explosion-proof casing; it is used to drive the TIIP10-3M starting fuel pump. Rated power — 60W, current drain — 6.6A maximum.

The M3K-2 electric unit is a reversible electric motor with electromagnetic braking and a five-stage planetary reduction gear; the unit opens and closes the shutters of the C-300 M gas turbine starter exhaust pipe at the beginning of starting and after its end, respectively.

The pneumatic contactor serves as a transmitter for operation of the M3K-2 unit.

The pneumatic contactor of the membrane type incorporates a contact unit (microswitch). The membrane chamber of the contactor is supplied with compressed air bled from the chamber after the compressor of the engine.

At an air pressure of 0.40—0.45 kg/cm² corresponding to engine speeds from 1,850 to 2,050 r.p.m. the pneumatic contactor closes the M3K-2 unit circuit for closing the shutter of the starter exhaust pipe. The contactor opens the circuit when the pressure of the supplied air drops below 0.35 kg/cm².

The pneumatic contactor may be set to operate at engine speeds from 1,850 to 2,050 r.p.m. by rotating its adjusting screw.

The CA-1895M electric motor is a series-excited machine intended to accelerate the C-300M gas turbine starter during starting.

The motor is turned on and off automatically by the IT-4B relay box. The box turns the motor off automatically as the starter gains a speed of 8,000—12,500 r.p.m.

The electromagnetic fuel valves admit starting fuel into the C-300M starter during the entire period of its operation.

The starter is provided with two such valves which operate simultaneously. One of the valves is installed before the TIIP-3P pump and the other

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after it in order to prevent fuel leaks after stopping the C-300M starter.

The units controlling engine starting (NT-4B box and TA-1 tachometer generator) ensure the required sequence of all the starting operations.

The TA-1 tachometer generator is a D.C. independent-excitation unit intended to supply the signal relays with the current whose voltage is built up proportionate to the engine speed.

The tachometer generator is installed on the C-300M starter and is rotated from the moment the starter begins to accelerate the engine to the moment when the starter is shut off.

The NT-4B relay box combines in one unit all the relays of the engine electrical equipment and serves as a central controlling element during engine starting. The relay box incorporates the following units: PMO-4B maximum speed relay; KM-200 contactor which controls operation of CA-189 BM motor; KM-100 engine ignition contactor; KM-25 contactor of engine starting fuel; two PNH-4 signal relays set to definite engine speeds; seven TKE52PK intermediate relays and one TKE53PK automatic starting relay; four resistors for setting the signal relays and one resistor for setting the PMO-4B relay.

Being set to certain engine speeds, the signal relays are alternately cut in and out of the tachometer generator circuit. Upon receiving a pulse from the tachometer generator, the signal relays turn on one intermediate relay or another, depending on the engine speed. The intermediate relays, in turn, operate the starting units required for the given engine speed. Engine starting is carried out on a fully automatic principle upon pressing the "Start" button (it is necessary previously to turn on the aircraft electrical system and shift the engine control lever to the "Idling" position).

Control units of the compressor blow-off band. The centrifugal transmitter and the electromagnetic air valve either open or close the compressor blow-off band to suit the engine speed. At an engine speed of 3,800-⁵⁰ r.p.m. and above the centrifugal transmitter turns on the power supply of the electromagnetic air valve with the help of a microswitch.

The valve admits compressed air (supplied from the aircraft air system through 52512700 air reducer) to the piston-type pneumatic unit which closes the air blow-off band from the compressor.

As the engine speed drops below 3,800-⁵⁰ r.p.m., the electromagnetic air valve is de-energized and stops supply of compressed air to the piston-type pneumatic unit which opens the air blow-off band by the force of the springs from the compressor.

Operation of the electromagnetic air valve for closing the air blow-off band on the imperative engine is effected by pressing a special button located on the right top part of the engine, near the centrifugal transmitter.

To reduce leakage of the fire-extinguishing gas from the engine nacelle in case of a fire, it is necessary to close the air blow-off band which will be accompanied by closing the nacelle shutter.

In order to synchronize closing of the air blow-off band with fuel supply shut off by the engine control lever in case of a fire the engine is fitted with type BK2-140PT limit switch which is interlocked with the engine control lever and cut into the circuit in series with the thermal warning units (four in number).

Upon operation of one of the thermal warning units, the pilot receives a signal calling for shutting down the engine.

At the moment the engine control lever is moved to the "Stop" position, the limit switch closes the air blow-off band.

Operation of Electrical Equipment

All the relays, switches and buttons are shown on the diagram in the "OFF" position.

Automatic Engine Starting (Fig. 17)

Turning on master switch 48 (with ABC-25 circuit breaker 49 turned on) supplies voltage to terminals 2, 3 and 8 of plug connector 54 and to the panel with starting buttons and switches. From terminal 2 of plug connector 54 the voltage is fed to terminal 6 of relay 60 and, through pneumatic contactor 20, to M3K-2 electric motor 6 (through terminals 9 of plug connector 21, terminal "I", normally-closed contacts and terminal "B" of pneumatic contactor, terminal 16 of plug connector 21, terminal "B" of plug connector 3 and terminal "3" of plug connector 7).

Type M3K-2 electric motor 6 starts rotating and opens the shutter of the C-300M starter exhaust pipe. About 6°-10° before complete opening of the shutter the signal contacts "A" of motor 6 close and the current is fed from terminal 3 of plug connector 54 through terminal "E" of plug connector 8, terminal 6 of plug connector 7, contact "A", terminal 5 of plug connector 7 to terminal "I" of plug connector 8 from where it is supplied through terminal 11 of plug connector 54 to pilot lamp 41 (which flashes up) and, in addition, to the winding of contactor 58 (terminal 1), thus preparing the contactor energizing circuit. Thus, contactor 58 provides for interlocking which prevents starting of the C-300M starter with its exhaust pipe shutter closed. The minus end of contactor 58 winding is connected to the minus busbar of the aircraft electrical system through contacts 2-3 of relay 60 after it is operated by pressing "Start" button 39.

From terminals 4 and 12 of plug connector 54 power is supplied to terminal 4 of contactor 57 and terminal 1 of contactor 18.

Electric power from terminal 3 of contactor 57 is fed to contact 2 of relay 61. On pressing "Start" button 39, current is fed through the button, and terminal 6 of plug connector 54 to the winding of relay 60 (terminal A and the minus end of the winding are constantly connected to the minus of the aircraft electrical system). Relay 60 is turned on and contacts 5-6, 2-3, 8-9 close.

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On releasing button 39, relay 60 remains in the ON position because its winding (terminal A) is supplied in this case through another circuit, from terminal 2 of plug connector 54 through closed relay contacts 5-6 and normally-closed contacts 5-4 of relay 56; this means that relay 60 is interlocked. Besides, electric power is fed from terminal 2 of plug connector 54 through closed contacts 6-5 of relay 60 to the field winding of tachometer generator 69 (from terminal 5 of relay 60, through terminal 6 of plug connector 65 and terminal "F" of tachometer generator plug connector). The minus end of the tachometer generator field winding is constantly connected to the aircraft electrical system through terminal "A" of its plug connector, terminal 7 of plug connector 65 and terminal 1 of plug connector 54. Power is also fed to terminal "A" of relay 62, terminal 2-3 of relay 70, terminal 3 of relay 16 and terminals 2 of relays 11, 12 and 17.

The following elements are connected to the minus of the aircraft electrical system through the closed contacts of relay 60: winding minus end of relay 16 (contact "B") through contacts 8-9, and winding minus end of contactor 58, winding minus end of PMO-4B relay 63 and terminal 3 of relay 56 through contacts 2-3. Therefore, on energizing relay 60 (by pressing the "Start" button), contactor 58 is turned on, then PMO-4B relay 63 is energized from terminal 3 of contactor 58 through normally closed contacts 5-4 of relay 61 (by means of the shunt winding supplied from the power circuit).

Upon operation of PMO-4B relay 63, the following units of the C-300M starter are set in operation:

a) CA-189EM electric motor 66 which starts accelerating the C-300M starter. Simultaneously, the series winding of PMO-4B relay 63 starts functioning; this winding is cut in series into the power circuit of the CA-189EM electric motor. The compensating winding of the PMO-4B supplied from the power circuit through adjustable resistor 64 also starts functioning. The adjustable resistor allows the PMO-4B to be set for the cut-out speed of the CA-189EM electric motor. The ampere-turns of the compensating winding counter-oppose the ampere-turns of the series winding.

b) The ignition system, because KPI-21 booster coil 68 is connected in parallel with the CA-189EM motor.

c) Electromagnetic fuel valves 67 through relay 61 whose winding is energized from terminal 4 of relay 63. The electromagnetic fuel valve starts supplying fuel to the C-300M starter. Electric power is fed to the electromagnetic valves from terminal 8 of plug connector 54 through closed contacts 2-3 of relay 61, through terminal 3 of plug connector 65, and terminal "B" of their own plug connector. Upon operation of relay 61, normally-closed contacts 5-4 open, thus de-energizing the shunt winding of relay 63. The latter remains "ON" as long as the force created by the series winding exceeds the joint forces of

the compensating winding and spring tending to turn off PMO-4B relay 63.

As the C-300M starter gains speed the turbine power also increases correspondingly; this is accompanied by a decrease in the current drained by the CA-189EM motor and, consequently, a decrease in the current flowing through the series winding of relay 63.

Due to a smaller force created by the series winding of the PMO-4B and under the force of the spring and compensating winding, PMO-4B relay 63 is automatically cut off as the starter speed reaches 8000-12500 r.p.m., consequently the CA-189EM motor is also turned off. Relay 61 remains "ON" (being supplied through contacts 5-6) providing for operation of the electromagnetic fuel valves up to the moment when all the automatic starting system is turned off. As the engine starts rotating (after engagement of the C-300M starter hydraulic clutch) tachometer generator 69 starts operating to develop a voltage proportionate to the engine speed and supply this voltage through terminals "B" and "B" of its own plug connector, terminals 5 and 8 of plug connector 65 to the windings of signal relays 11 and 12. From terminal 8 of plug connector 65 electric power is supplied by the tachometer generator through normally-closed contacts 5-4 of relays 62, 72 and 16 to the windings of relay 12 (to terminal 3 past rheostat 14 and to terminal 5 through rheostat 14).

Thus, the windings of signal relay 12 are initially cut into the tachometer generator circuit. As the engine gains a speed of 220-280 r.p.m., the voltage built up by the tachometer generator becomes sufficient for operation of relay 12. Signal relay 12 is turned on and supplies power through its closed contacts 2-1 and through normally closed contacts 2-1 of relay 72 to the windings of contactor 57 (to terminal "A") and contactor 18 (to terminal 4).

Besides, voltage is fed to terminal 2 of relay 16 and terminal "F" of signal plug connector 19. Contactors 57 and 18 start operating and turn on the ignition system and the starting pump (from the aircraft electrical system power is supplied through terminals 4 and 12 of plug connector 54, through closed contacts 4-3 and 1-2 of contactor 57, terminal 7 of plug connector 21 and intermediate plug connectors to booster coil units 24, thus turning on the ignition system; the electric motor of starting fuel pump 30 and electromagnetic fuel valve 31 are supplied through closed contacts 1-2 of contactor 18, terminal 13 of plug connector 21 and through the intermediate plug connectors).

Simultaneously power is supplied to terminal "A" of plug connector 19. Besides energizing the ignition system, the current flows from terminal 1 of contactor 57 to operate relay 16 (terminal "A"). Upon operation of relay 16 its contacts 5-4 open and contacts 5-6 close, thereby disconnecting the windings of relay 12 from the tachometer generator circuit and connecting the windings of signal relay 11 (one winding through

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On releasing button 39, relay 60 remains in the ON position because its winding (terminal 4) is supplied in this case through another circuit: from terminal 2 of plug connector 54 through closed relay contacts 2-3 and normally-closed contacts 5-4 of relay 61. This means that relay 60 is interlocked. Besides, electric power is fed from terminal 2 of plug connector 54 through closed contacts 2-3 of relay 60 to the field winding of tachometer generator 69 (from terminal 5 of relay 60, through terminal 6 of plug connector 60 and terminal "T" of tachometer generator plug connector). The minus end of the tachometer generator field winding is constantly connected to the aircraft electrical system through terminal "A" of its plug connector, terminal 7 of plug connector 60 and terminal 1 of plug connector 54. Power is also fed to terminal "A" of relay 62, terminals 1-5 of relay 70, terminal 3 of relay 16 and terminals 2 of relays 11, 12 and 17.

The following elements are connected to the minus of the aircraft electrical system through the closed contacts of relay 60: winding minus end of relay 16, contact "B" through contacts 8-9 and winding minus end of contactor 58, winding minus end of PMO-4B relay 63 and terminal 3 of relay 55 through contacts 2-3. Therefore, on energizing relay 60 (by pressing the "Start" button), contactor 58 is turned on, then PMO-4B relay 63 is energized from terminal 3 of contactor 58 through normally closed contacts 5-4 of relay 61 (by means of the shunt winding supplied from the power circuit).

Upon operation of PMO-4B relay 63, the following units of the C-300M starter are set in operation:

a) CA-1895M electric motor 66 which starts accelerating the C-300M starter. Simultaneously the series winding of PMO-4B relay 63 starts functioning, this winding is cut in series into the power circuit of the CA-1895M electric motor. The compensating winding of the PMO-4B supplied from the power circuit through adjustable resistor 64 also starts functioning. The adjustable resistor allows the PMO-4B to be set for the cut-out speed of the CA-1895M electric motor. The ampere-turns of the compensating winding counter-oppose the ampere-turns of the series winding.

b) The ignition system, because K1-21 booster coil 65 is connected in parallel with the CA-1895M motor.

c) Electromagnetic fuel valves 67 through relay 61 whose winding is energized from terminal 4 of relay 60. The electromagnetic fuel valves start supplying fuel to the C-300M starter. Electric power is fed to the electromagnetic valves from terminal 4 of plug connector 54 through closed contacts 2-3 of relay 61, through terminal 1 of plug connector 65, and terminal "B" of their plug connector. Upon operation of relay 61, normally-closed contacts 5-4 open, thus de-energizing the shunt winding of relay 63. The compensating winding of relay 63 remains energized as long as the force created by the series winding exceeds the joint forces of

the compensating winding and spring tending to turn off PMO-4B relay 63.

As the C-300M starter gains speed the turbine power also increases correspondingly; this is accompanied by a decrease in the current drained by the CA-1895M motor and, consequently, a decrease in the current flowing through the series winding of relay 63.

Due to a smaller force created by the series winding of the PMO-4B and under the force of the spring and compensating winding, PMO-4B relay 63 is automatically cut off as the starter speed reaches 8,000-12,500 r.p.m.; consequently the CA-1895M motor is also turned off. Relay 61 remains "ON" (being supplied through contacts 5-6) providing for operation of the electromagnetic fuel valves up to the moment when all the automatic starting system is turned off. As the engine starts rotating (after engagement of the C-300M starter hydraulic clutch) tachometer generator 69 starts operating to develop a voltage proportionate to the engine speed and supply this voltage through terminals "B" and "B" of its own plug connector, terminals 5 and 6 of plug connector 65 to the windings of signal relays 11 and 12. From terminal 8 of plug connector 65 electric power is supplied by the tachometer generator through normally-closed contacts 5-4 of relays 62, 72 and 16 to the windings of relay 12 (to terminal 3 past rheostat 14 and to terminal 5 through rheostat 14).

Thus, the windings of signal relay 12 are initially cut into the tachometer generator circuit. As the engine gains a speed of 220-280 r.p.m., the voltage built up by the tachometer generator becomes sufficient for operation of relay 12. Signal relay 12 is turned on and supplies power through its closed contacts 2-1 and through normally closed contacts 2-1 of relay 72 to the windings of contactor 57 (to terminal "A") and contactor 16 (to terminal 4).

Besides, voltage is fed to terminal 2 of relay 16 and terminal "T" of signal plug connector 19. Contactors 57 and 16 start operating and turn on the ignition system and the starting pump (from the aircraft electrical system power is supplied through terminals 4 and 12 of plug connector 57, through closed contacts 4-3 and 1-2 of contactor 57, terminal 7 of plug connector 21 and intermediate plug connectors to booster coil units 29, thus turning on the ignition system; the electric motor of starting fuel pump 30 and electromagnetic fuel valve 31 are supplied through closed contacts 1-2 of contactor 16, terminal 13 of plug connector 21 and through the intermediate plug connectors).

Simultaneously power is supplied to terminal "A" of plug connector 19. Besides energizing the ignition system, the current flows from terminal 1 of contactor 57 to operate relay 16 (terminal "A"). Upon operation of relay 16 its contacts 5-4 open and contacts 5-6 close, thereby disconnecting the windings of relay 12 from the tachometer generator circuit and connecting the windings of signal relay 11 (one winding through

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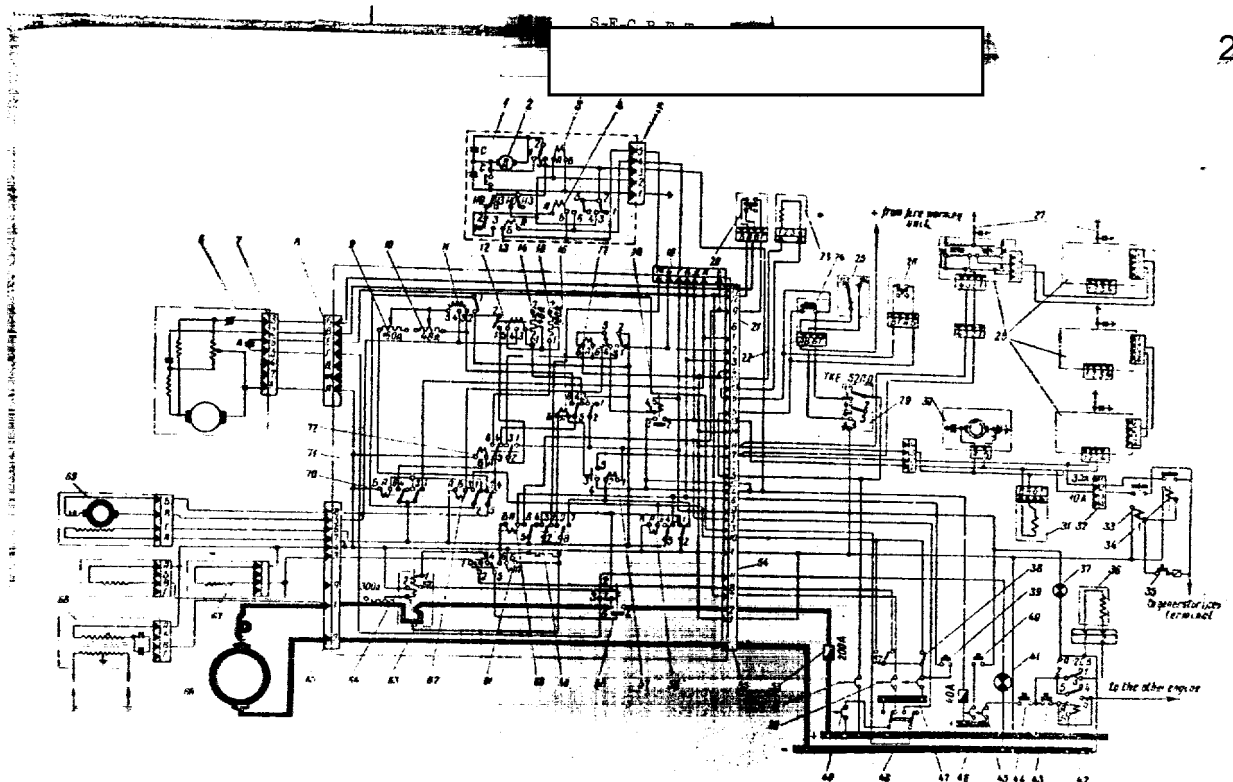


Fig. 17 Wiring Diagram

Fig. 17 Wiring Diagram. This diagram shows the electrical connections for the engine control system. The central unit is connected to various sensors and actuators. The wiring paths are indicated by lines and numbers. The diagram is a detailed schematic of the engine control system.

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rheostat 10, the other — past the rheostat. Besides, closed contacts 3—2 of relay 16 create the second interlocking supply circuit of the windings of contactors 57 and 18.

At an engine speed of about 400 r.p.m. signal relay 11 operates and power is supplied through its closed contacts, and normally closed contacts 2—1 of relay 62 to the winding of relay 70 (terminal "A"). Relay 70 is put in operation and gets interlocked through its closed contacts 2—3.

Closing of contacts 5—6 of relay 70 causes opening of contacts 4—5 of relay 72 and closing of its contacts 5—6, this disconnects relay 11 from the tachometer generator circuit and connects relay 12 to it. In this case one winding of relay 12 is connected through rheostat 15 and the other — through rheostats 15 and 14.

This operation (i.e. operation of relay 11) in the PD-3M engine was used to open one HTP valve; in the PD-3M 500 engine this operation has been cancelled. At an engine speed of 740—880 r.p.m., relay 12 operates again and supplies power to the winding of relay 17 (terminal "A") through its closed contacts 2—1 and through contacts 2—3 of relay 72. Relay 17 is turned on and interlocked through its own closed contacts 2—3.

Opening of contacts 5—4 of relay 17 breaks the winding minus circuit of contactor 18; the contactor turns off and cuts out the starting fuel pump. The ignition system remains "ON" for exercising the spark plugs. The winding minus of relay 62 (contact "B") is connected to the minus of the aircraft electrical system through closed contacts 5—6 of relay 17. Relay 62 functions.

As a result of opening of contacts 5—4 and closing of contacts 5—6 of relay 62, relay 12 is disconnected from the tachometer generator circuit while relay 11 is connected instead, in this case through rheostats 9 and 10.

As the engine develops a speed of 1,150—1,250 r.p.m., relay 11 operates and voltage is supplied to the winding of relay 56 (terminal "A") through closed contacts 2—1 of relay 11 and contacts 2—3 of relay 62.

Upon operation of relay 56, its normally closed contacts 5—4 open, thus breaking the supply circuit of the winding of automatic starting relay 60; this turns off the entire electric automatic starting system, i.e. engine ignition system is turned OFF, so is KM-200 contactor 58 and, lastly, relay 61 is also turned off to de-energize the electromagnetic valves which shut off the fuel supply line of the C-300M starter. The starter is then shut down and the engine gains idling speed under its own power.

Upon completion of engine starting, at 1,650—2,050 r.p.m. the increased pressure after the compressor puts pneumatic contactor 20 in operation, thereby closing the supply circuit contacts of electric motor 6 for closing the exhaust pipe shutter of the C-300M starter.

Power is fed to the motor winding from terminal 9 of plug connector 54 through terminal 9

of plug connector 21, terminal "I", closed contact and plug connector terminal "A" of pneumatic contactor 20, terminal 12 of plug connector 21, terminal "B" of plug connector 8, terminal 2 of plug connector 7, and through the closed contacts of the M3K-2 mechanism.

The electric motor of mechanism 6 closes the exhaust pipe shutter of the C-300M starter thus protecting the latter against autorotation in flight. At the same time the signal contacts "A" of mechanism 6 are opened by its cam, thereby breaking the winding supply circuit of contactor 58. This renders starting of the starter impossible with the engine running at speeds higher than 1,850—2,050 r.p.m. Mechanism 6 likewise closes the starter exhaust pipe shutter when master switch 48 is turned off. In this case electric power is fed to the electric mechanism through terminal 7 of plug connector 54 and further along the same route as for operation of pneumatic contactor 20.

As the engine develops a speed of 3,800 r.p.m. centrifugal transmitter 26 is set in operation. Through the transmitter limit switch voltage is then fed from the aircraft electrical system (terminals 5 of plug connector 54 and terminals 6, 6, 10 of plug connector 21) to electromagnetic air valve 23 which admits compressed air into the air blow-off band control mechanism. Connected in parallel with the centrifugal transmitter limit switch is button 21 which makes it possible to close the air blow-off band with the engine at rest.

Cold Cranking of Engine

Turning on master switch 48 prepares the electric automatic system for cold cranking. After switching on engine cold cranking switch 38 power is fed from terminal 10 of plug connector 54 to the winding of relay 56. Operation of this relay (closing of contacts 2—3) turns on contactor 58 which, in turn, switches on the shunt winding of relay 63.

Relay 63 supplies CA-1895M electric motor 66, KM-21 booster coil and the winding of relay 67 (from terminal 4 of relay 63).

Upon operation of relay 61, contacts 5—4 open the shunt winding circuit of the PMO-4B relay; relay 61 becomes interlocked by closed contacts 5—6, while contacts 2—3 supply electric power to electromagnetic fuel valve 67.

The C-300M starter is then started and begins to crank the engine. To stop cold cranking of the engine, it is necessary to turn off switch 38 thus turning off relay 56, contactor 58 and relay 61, and shutting off the supply of fuel to the C-300M starter.

Cold Cranking of Starter

To cold crank the starter, turn on master switch 48 and "Starter cold cranking" switch 52. The operating sequence of all the automatic starting system elements is the same as during cold cranking of the engine with the only difference

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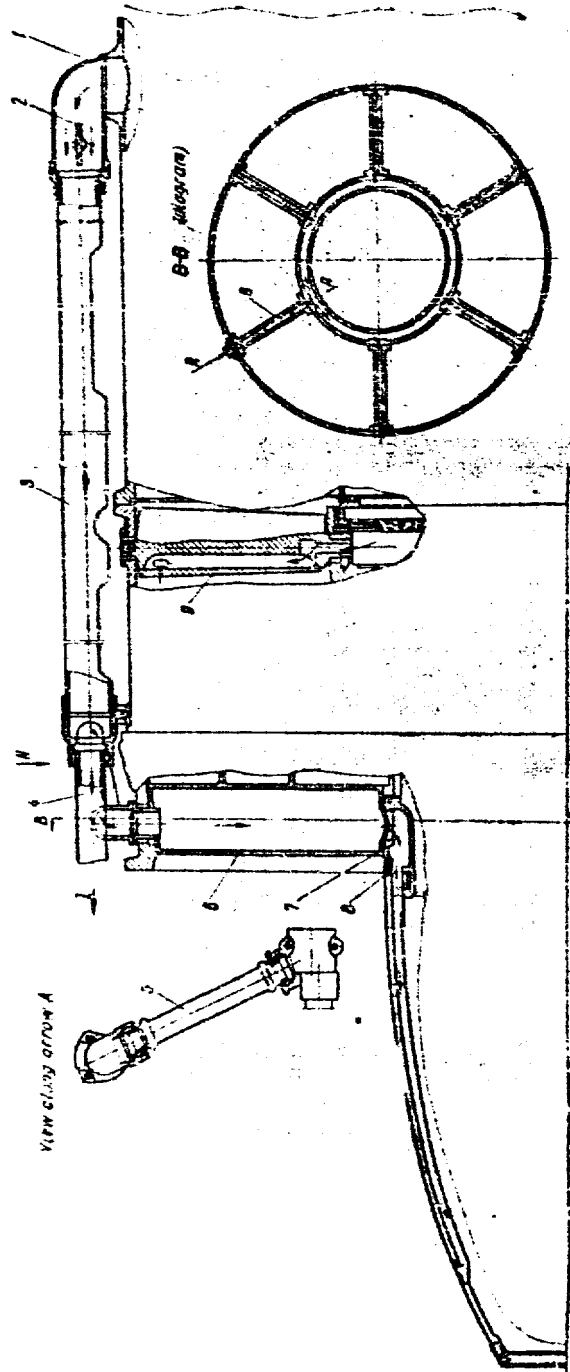


Fig. 18. Engine Anti-icing System:

1 - air bleed valve; 2 - throttle valve; 3 - anti-icing system air inlet pipe; 4 - air feed pipe into diffuser; 5 - air feed pipe into diffuser; 6 - air feed pipe into diffuser; 7 - support; 8 - bearing; 9 - guide valve; 10 - for shut off diffuser during

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that shifting the "Starter cold cranking" switch to the other extreme position will break the supply circuit of the starter electromagnetic valves. As a result, there would be no fuel supply to the starter and the latter will not start.

Starting in Flight

Engine starting in flight is carried out automatically. To start the engine, turn on A3C-5 circuit breaker (46) and press "In-Flight Starting" button 40 for 2 seconds. This will connect the plus of the aircraft electrical system through "In-Flight Starting" button 40 to the following units:

- a) to pilot lamp 37 of A3J-60 time relay 1;
- b) to control windings of ignition contactor 57 and starting fuel contactor 18 through terminal 9 of plug connector 51;
- c) to the winding of relay 13 through terminal 9 of plug connector 51, terminal "I" of plug connector 19, and terminal 2 of plug connector 5. Relay 13 operates and supplies electric power to the winding of relay 4 through its own contacts 2-3 and "O-HO" contacts of disc switch "A". Relay 4 operates and supplies electric power through its contacts 2-3 to the winding of relay 3 while through contacts 5-6 relay 13 is interlocked on one side, and contactors 57 and 18 and pilot lamp 37 are interlocked on the other side; thus, ignition current and starting fuel are supplied in the course of 56.5 seconds.

Relay 3 is put in operation and, through its contacts 2-3, turns on A-2P electric motor 1 of the programming mechanism. Motor 1 starts rotating and begins driving the programming disc shaft. In two seconds relay 3 is interlocked through the closed contacts "O-HO" of disc switch "O" and is held "ON" in the course of 60 seconds.

Emergency Starting in Flight

Emergency starting in flight includes simultaneous supply of starting fuel and ignition current to the engine that has accidentally stalled in flight; in this case PNH10-3M starting pump 30 and KPH4-2PI booster coil units 28 are supplied by the generators working at engine auto-rotation speed. The starting fuel and ignition should be supplied by long depression of "In-Flight Starting" button 35. This turns on emergency starting contactors 30 and 34 while operation of the starting pump and ignition system is ensured through terminals 2 and 4 of emergency starting plug connector 32.

Use of Emergency Rating

Before shifting over to emergency rating, it is necessary to turn on A3C-5 circuit breaker 45 and interlock mechanically button 44. This will

feed electric power from the aircraft electrical system through A3C-5 circuit breaker 45 and button 44 to terminals 2 and 5 of relay 42, thereby preparing the "ON" circuit of electromagnetic valve 36. Pressing button 44 puts relay 42 in operation after which voltage is fed from the aircraft electrical system through terminal 2 of the plug connector to the winding of electromagnetic valve 36 which increases the fuel supply and, consequently, raises engine speed above the maximum rating. (The minus end of the electromagnet winding is connected to the aircraft electrical system through terminal 1 of the plug connector). The emergency rating should be resorted to for not longer than 2 minutes.

9. ANTI-ICING SYSTEM

The engine is provided with an anti-icing system which prevents formation of ice on the engine air intake parts under the high humidity conditions of ambient air at temperatures close to 0°C.

The anti-icing system (Fig. 18) ensures heating of the necessary parts with hot air bled from the 7th and 5th stages of the compressor.

Air bleed valve 1 of the throttle type is installed after the compressor 7th stage on the middle casing. Throttle valve 2 of the air bleed valve is opened under the pressure of the compressed air fed to the valve when the anti-icing system is "ON", and is closed by the spring when the anti-icing system is "OFF" and supply of compressed air ceases. Supply of compressed air to the air bleed valve is controlled manually. The air from the compressor air bleed valve passes through pipe 3 extending outside the engine and is fed to the following units:

- a) Through diffuser adapter and one of covering struts 6 (the top left one) into the manifold of support 7 of the compressor front casing and thence into other covering struts 6 and into the double wall of turbine starter fairing 8.
- b) To diffuser and exhaust pipe of the gas-turbine starter.

The edges of compressor guide vanes 9 are heated with air bled from the front relief chamber which is taken off after the compressor 5th stage and delivered into the front chamber through holes drilled in the discs of the first five stages of the compressor.

Having heated all the above mentioned surfaces, the air joins the main air flow at the engine intake.

10. ENGINE MOUNTING

The P2-3M-500 engine is secured to the side wall of the airplane fuselage. Depending on whether

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Chapter III **BRIEF DESCRIPTION OF C-300M STARTER, 6TH SERIES** (Figs. 21 and 22)

The C-300M gas turbine starter is intended to provide independent automatic starting of the engine. The starter is cantilever-mounted on the frame of the engine central drive and is enclosed in a fairing.

The major component parts of the starter are as follows (Fig. 23):

- centrifugal compressor 5, 6;
- annular combustion chamber 4;
- single stage gas turbine 2;
- exhaust unit 7;
- reduction gear with hydraulic clutch 7, 8.

The combustion chamber is of a welded annular construction specially shaped to provide for turbulence of the gas flow.

Turbulence of the flow in conjunction with the specific arrangement of the holes in the chamber walls insures normal formation of mixture and steady combustion at all the service ratings of the starter.

The combustion chamber is enclosed in a cylindrical casing welded of heat-resistant sheet steel IX18H9T. The combustion chamber proper is made from heat-resistant sheet steel 3H-802.

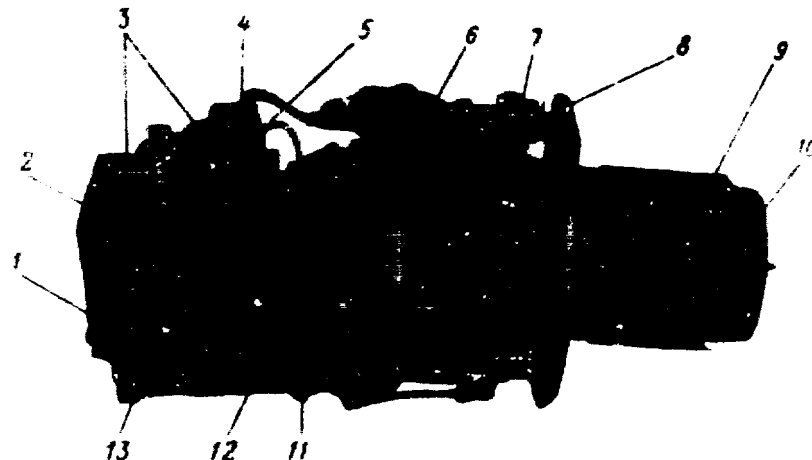


Fig. 21. C-300M Starter, Right-Hand View

1 - T-043 tachometer generator; 2 - C-1A100M electric starter; 3 - electromagnetic fuel valves; 4 - annular combustion chamber; 5 - 1A100M electric starter; 6 - 1A100M electric starter; 7 - 1A100M electric starter; 8 - 1A100M electric starter; 9 - 1A100M electric starter; 10 - 1A100M electric starter; 11 - 1A100M electric starter; 12 - 1A100M electric starter; 13 - 1A100M electric starter.

accessory drives.

The starter compressor of the centrifugal type consists of a casing, intake pipe with a protective screen, impeller, and a vaned diffuser.

The compressor impeller and diffuser are made, respectively, of AK 4 aluminum alloy and M1 5 magnesium alloy.

The vanes of the turbine nozzle assembly are installed at the circular outlet of the combustion chamber.

The starter turbine comprises the nozzle assembly and shaft-mounted bladed disc. The other end of the shaft carries the compressor impeller. The shaft rotates in two rolling action bearings.

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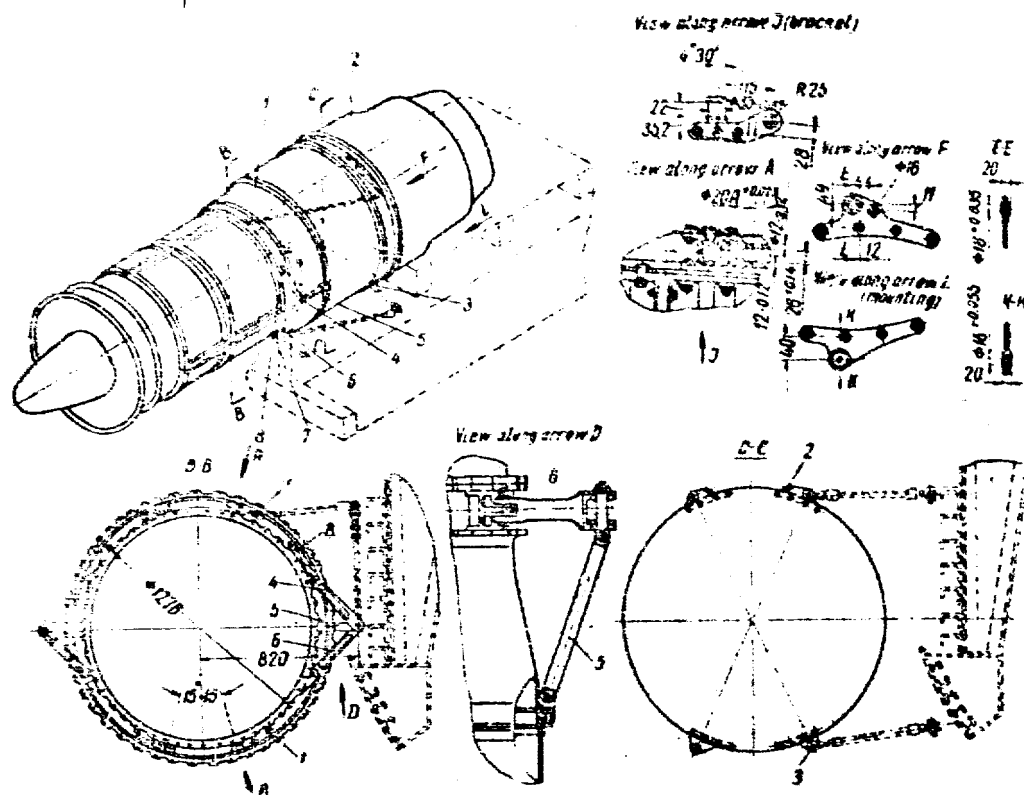


Fig. 19 Engine Mount.

Upper front mounting bracket; 2 - upper rear mounting bracket; 3 - lower rear mounting bracket; 4, 5 - load carrying aircraft beams; 7 - lower front mounting bracket; 8 - front mount for handling engine

the engine is secured to the L.H. or R.H. wall of the fuselage, the engines are distinguished as the L.H. or R.H. type.

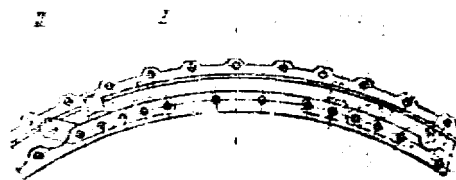


Fig. 20 Location of Engine Lower Mounting Bracket:
I - for TV-8 aircraft; II - for TV-10 aircraft

The main attachment surface of the engine is situated in the front part of the compressor rear casing (in close proximity to the engine center of gravity). This surface of the engine is provided with two brackets and a three-spindle mount, symmetrical for the R.H. and L.H. engines.

The second attachment surface is located at the front end of the nozzle assembly casing of the turbine 1st stage. This surface of the engine is provided with two brackets located symmetrical for the R.H. and L.H. engines (see Fig. 19).

Depending on the type of airplane, the lower mounting bracket of the engine (Fig. 19) can be installed in either of the two positions (Fig. 20).

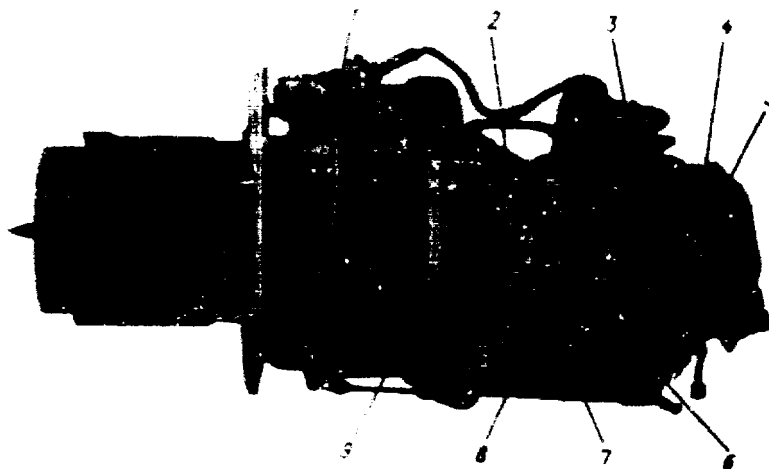
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The KII-21 booster coil is installed on the L.H. upper side, on the bracket which is secured to the starter reduction gear.

Starter operating principle. During starting, the starter rotor is accelerated by the CA-189BA starting motor.

Atmospheric air enters the starter through the ports in its fairing. Passing through the protective screen and the intake pipe the air flows onto the compressor impeller at a rate of 15 kg/sec. Being compressed in the compressor (compression ratio 2.9), the air enters the combustion chamber where it is mixed with the fuel



4. 2. 30AM Starter Left-Hand 1st

1 - fuel pump to engine; 2 - oil pressure pick-up unit in engine; 3 - starter to engine; 4 - average section of outlet pipe; 5 - starter oil drain; 6 - oil feed pipe which carries oil to the engine; 7 - average section of inlet pipe; 8 - combustion chamber drain.

the valve is opened and closed automatically by a 110-volt electric motor mounted on the ex-
haustion by a pneumatic con-

delivered from the injectors and participates in the process of combustion. The combustion gases produce energy for rotating the turbine wheel and are then discharged through the exhaust system of the starter.

As the starter speed reaches 8,000-12,500 r.p.m., the overspeed relay cuts off the starting electric motor from the starting electrical system. Mechanical disengagement of the electric motor from the starter rotor is done by the overrunning clutch.

Further acceleration of the starter to the working speed (31,800—33,500 r.p.m.) is effected by the starter turbine alone. Control of starter acceleration and maintenance of the constant starter speed during acceleration of the engine are taken care of by the THP-3P regulating fuel pump which also controls the reduction gear hydraulic clutch.

The effective power of the starter (90-100 HP) is transmitted for accelerating the engine motor through the reduction gear with 0.0415 ratio, and a ratchet clutch.

The reduction gear consists of two meshing gears and a hydraulic clutch which permits the reduction gear transmission when the rotor is idlerative. As oil begins to be pumped the hydraulic clutch (at a certain R.P.M.), the reduction gear becomes engaged and the rotor begins to accelerate the engine rotor.

Arrangement of starter units. Mounted external to the starter are the following units

regulating fuel pump — on the front wall
 starter reduction gear, bottom right; two-
 speed pump — bottom left, T.D. tachometer
 — on top

10-4a R/R M. transmitter drive

The 100 amp 115-180v AC electric starter
motor drive has electromagnetic
overload protection and on the B H wall

A-B-C-R-E-T

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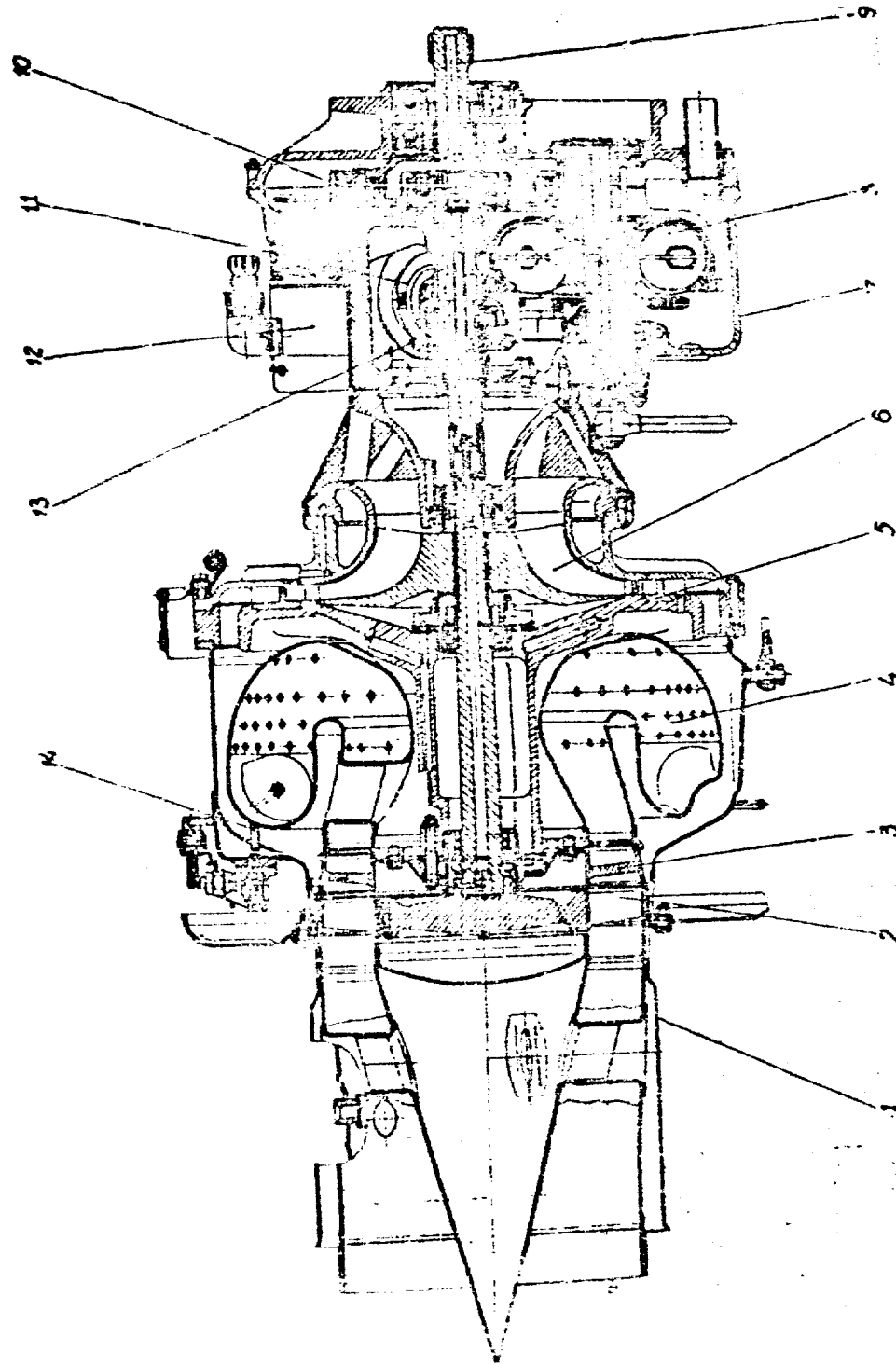


Fig. 23. C-300M Starter. Diagrammatic View:
 1 - engine drive coupling; 2 - turbine; 3 - turbine waste assembly; 4 - annular combustion chamber; 5 - compressor; 6 - compressor dilator; 7 - compressor impeller; 8 - turbine waste assembly; 9 - engine drive coupling; 10 - turbine waste assembly; 11 - turbine waste assembly; 12 - turbine waste assembly; 13 - turbine waste assembly; 14 - turbine waste assembly.

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Attachment to

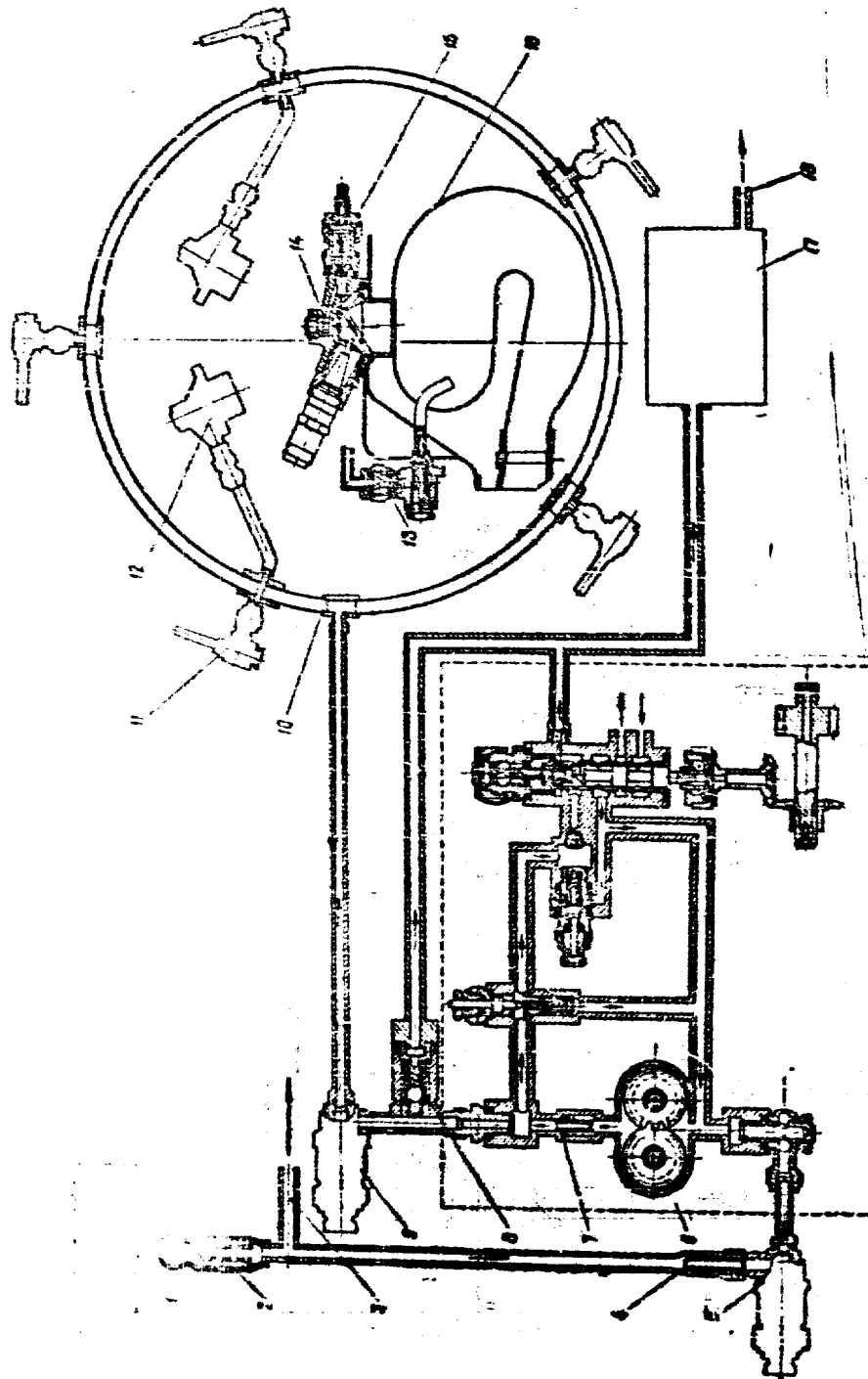


Fig. 24. C-400M Starter Fuel System.

1 - starting fuel tank; 2 - filter on engine; 3 - fuel discharge to filter; 4 - filter on engine; 5 - 1st electromagnetic fuel valve; 6 - 2nd electromagnetic fuel valve; 7 - 3rd electromagnetic fuel valve; 8 - 4th electromagnetic fuel valve; 9 - 5th electromagnetic fuel valve; 10 - 6th electromagnetic fuel valve; 11 - fuel manifold; 12 - main burner; 13 - main burner return valve; 14 - discharge to atmosphere; 15 - discharge to atmosphere; 16 - discharge to atmosphere; 17 - discharge to atmosphere; 18 - discharge to atmosphere; 19 - discharge to atmosphere; 20 - discharge to atmosphere; 21 - discharge to atmosphere; 22 - discharge to atmosphere; 23 - discharge to atmosphere; 24 - discharge to atmosphere; 25 - discharge to atmosphere; 26 - discharge to atmosphere; 27 - discharge to atmosphere; 28 - discharge to atmosphere; 29 - discharge to atmosphere; 30 - discharge to atmosphere; 31 - discharge to atmosphere; 32 - discharge to atmosphere; 33 - discharge to atmosphere; 34 - discharge to atmosphere; 35 - discharge to atmosphere; 36 - discharge to atmosphere; 37 - discharge to atmosphere; 38 - discharge to atmosphere; 39 - discharge to atmosphere; 40 - discharge to atmosphere; 41 - discharge to atmosphere; 42 - discharge to atmosphere; 43 - discharge to atmosphere; 44 - discharge to atmosphere; 45 - discharge to atmosphere; 46 - discharge to atmosphere; 47 - discharge to atmosphere; 48 - discharge to atmosphere; 49 - discharge to atmosphere; 50 - discharge to atmosphere; 51 - discharge to atmosphere; 52 - discharge to atmosphere; 53 - discharge to atmosphere; 54 - discharge to atmosphere; 55 - discharge to atmosphere; 56 - discharge to atmosphere; 57 - discharge to atmosphere; 58 - discharge to atmosphere; 59 - discharge to atmosphere; 60 - discharge to atmosphere; 61 - discharge to atmosphere; 62 - discharge to atmosphere; 63 - discharge to atmosphere; 64 - discharge to atmosphere; 65 - discharge to atmosphere; 66 - discharge to atmosphere; 67 - discharge to atmosphere; 68 - discharge to atmosphere; 69 - discharge to atmosphere; 70 - discharge to atmosphere; 71 - discharge to atmosphere; 72 - discharge to atmosphere; 73 - discharge to atmosphere; 74 - discharge to atmosphere; 75 - discharge to atmosphere; 76 - discharge to atmosphere; 77 - discharge to atmosphere; 78 - discharge to atmosphere; 79 - discharge to atmosphere; 80 - discharge to atmosphere; 81 - discharge to atmosphere; 82 - discharge to atmosphere; 83 - discharge to atmosphere; 84 - discharge to atmosphere; 85 - discharge to atmosphere; 86 - discharge to atmosphere; 87 - discharge to atmosphere; 88 - discharge to atmosphere; 89 - discharge to atmosphere; 90 - discharge to atmosphere; 91 - discharge to atmosphere; 92 - discharge to atmosphere; 93 - discharge to atmosphere; 94 - discharge to atmosphere; 95 - discharge to atmosphere; 96 - discharge to atmosphere; 97 - discharge to atmosphere; 98 - discharge to atmosphere; 99 - discharge to atmosphere; 100 - discharge to atmosphere.

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As the engine gains a speed of 1,150—1,250 r.p.m., the starter is shut down and the ratchet clutch disengages it from the engine. Shutting down of the starter is done by cutting off the fuel supply by means of the electromagnetic valves connected to the electrical starting system.

The starter fuel system (Fig. 24) ensures the supply of accurately metered portions of fuel into the combustion chamber of the starter. A gear pump forces fuel into the circular manifold which feeds five main burners and two starting burners of the igniters. All the injectors are of the centrifugal atomization type. Both the main and starting burners are fitted with return valves set for opening pressures of 0.8—0.9 and 0.4—0.5 kg/cm², respectively.

Therefore, during starter starting, the fuel is fed into the combustion chamber initially through the starting burners thereby ensuring efficient atomization and ignition of the fuel.

During subsequent operation of the starter up to the moment of its disengagement, the fuel is delivered into the combustion chamber through

the main burners, though the starting burners continue functioning too.

The fuel is injected into the combustion chamber through the main burners tangentially with respect to the chamber. With this purpose in view, the ends of the main burners are curving at an angle of about 90°.

To prevent vapour locks and ensure reliable starting of the gas-turbine starter at the first attempt, the system incorporates an automatic relief valve which discharges the gasoline fumes and air into the engine drain tank.

The THP-3P regulating fuel pump (Fig. 25) supplies metered quantities of fuel into the starter combustion chamber, and bypasses oil into the hydraulic clutch.

The regulating fuel pump consists of fuel pump 1 and a centrifugal governor.

The gear fuel pump is located in the lower part of the governor. The pump gears rotate in needle bearings. A double rubber sealing collar seals the pump at the drive shaft end. Screen filter 2 is located at the delivery section outlet.

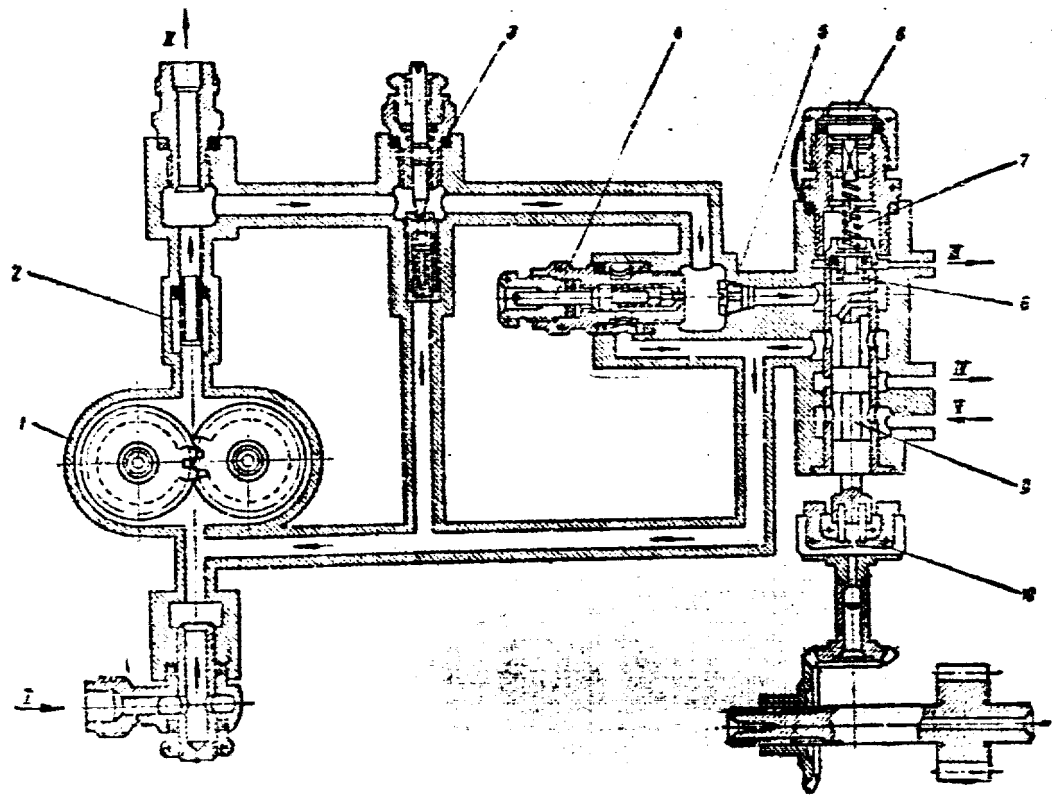


Fig. 25 THP-3P Regulating Fuel Pump Diagram.

1—fuel pump; 2—screen filter; 3—starting control screw; 4—pressure control valve; 5—jet; 6—centrifugal governor screw; 7—fuel line; 8—fuel line; 9—fuel line; 10—fuel line; 11—fuel line; 12—fuel line; 13—fuel line; 14—fuel line; 15—fuel line.

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To diminish the effect of beating on the pump performance, the pump capacity is made to exceed considerably the required value. The surplus fuel is discharged through starting control screw 3. To prevent fuel leaks at the beginning of starting, when the pump speed and capacity are low, the by-pass hole of screw 3 is closed with a ball valve.

Mounted on the splines of the pump drive gear shaft is a bevel gear which rotates in a ball bearing and transmits rotation to a gear and fork with centrifugal weights, and to control valve 2. The ends of the weight arms bear through the needles against the control valve, moving it inside the steel sieve.

The control valve has three bands: the lower sealing band at the side of the weights, the middle band serving to bypass oil into the hydraulic clutch, and the upper band used to bypass fuel from the high-pressure chamber to the suction side to prevent the starter from racing and to maintain its working speed.

The upper band of the control valve is provided with four through holes which are arranged at assembly under the bypass port of the sleeve. The valve is held in this position by spring 8 whose tension is adjusted to 130 g.

During starter starting, at a speed of about 2,000 r.p.m., the force of the centrifugal weights

overcomes the resistance of the spring and the holes of the control valve come against the port in the sleeve. This results in partial bypassing of fuel which reduces considerably the temperature during starting.

The upper end of the control valve is loaded through a ball bearing by spring 7 whose tension may be changed by adjusting screw 6 which is used to set the working speed of the starter. The necessary amount of fuel to be supplied at this speed is set by pressure control valve screw 4.

The amount of fuel drained through the control valve at idling speed is regulated by jet 5.

The fuel consumption during acceleration of the starter is regulated by the starting control screw 3 which bypasses part of the fuel into the drain line.

The fuel seeping through the control valve of the centrifugal governor is discharged from this valve into the drain tank.

The electrical system serves for automatic starting and stopping of the starter.

The ignition system, comprising a KP-21 booster coil, and two CD-55AHM spark plugs, as well as igniters, type CA-189BM starting electric motor and two electromagnetic fuel valves, is turned on and off by the relay box mounted on the engine.

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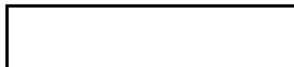
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